

DARING DOGSLEDDERS

Denmark's Elite Patrol

ULTIMATE SURVIVORS

Life After Land Mines

MONTANA STALWARTS

Today's Homesteaders

NGM.COM JANUARY 2012

NATIONAL GEOGRAPHIC



TWINNS

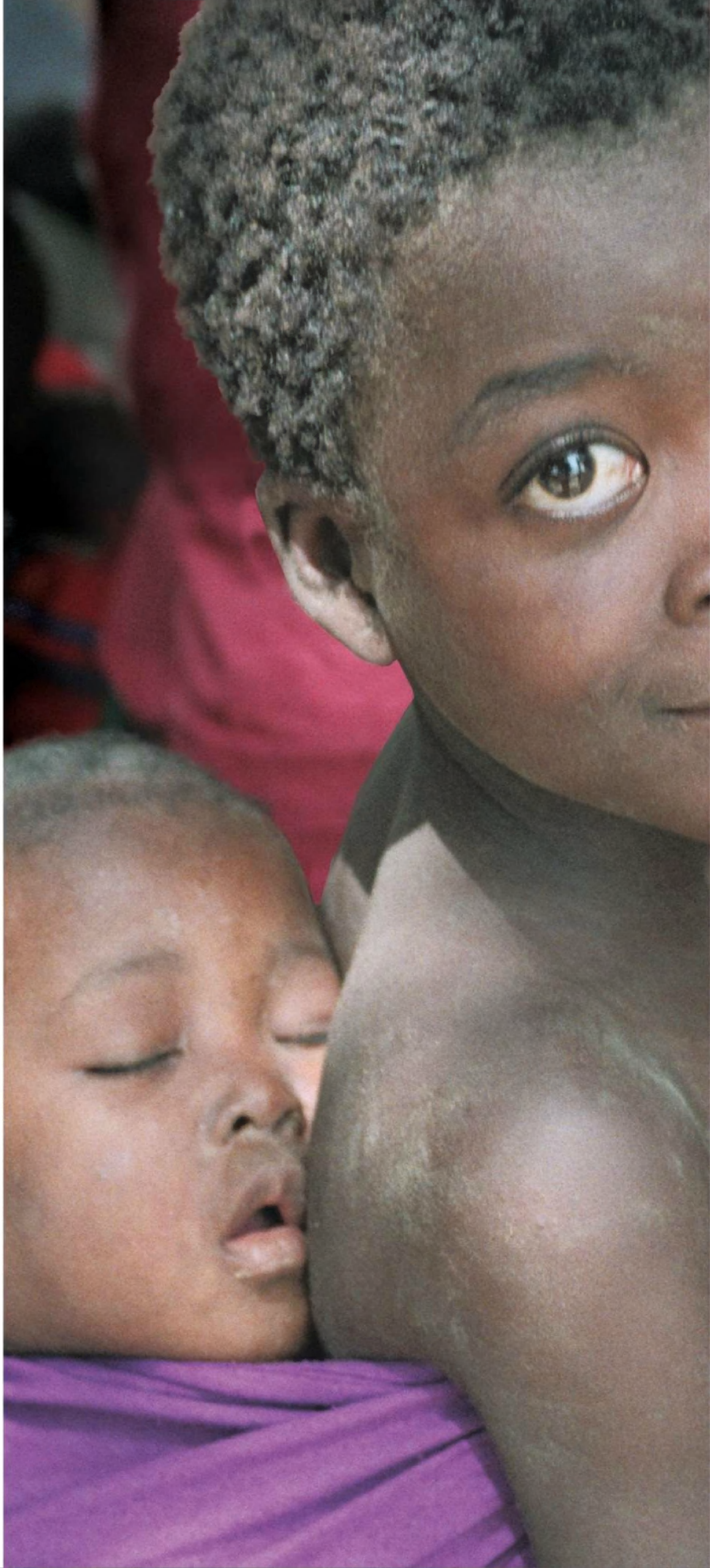
ALIKE BUT NOT ALIKE



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Measles remains a deadly killer that threatens children worldwide. The Measles Initiative, which has supported the vaccination of more than 700 million children in over 60 countries, is a partnership committed to reducing measles mortality.

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A life-saving vaccine against measles has been available since the 1960's; yet measles remains a leading cause of vaccine-preventable deaths in the world. Immunization for every at-risk child is the objective of the Measles Initiative.

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¹ FORTUNE®, March 2011, ² Ethisphere™ Magazine, April 2011
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Bonin White-eye (*Apalopteron familiare*)

Size: Head and body length, approx. 14 cm **Weight:** 13 - 15 g **Habitat:** Low secondary forests and forest edges on three of the Ogasawara (also known as Bonin) Islands **Surviving number:** Estimated at 10,000 - 15,000



Photographed by Akira Ozono

WILDLIFE AS CANON SEES IT

And then there was one. The only endemic bird remaining on the Ogasawara Islands, the Bonin white-eye has seen the teeming subtropical forests it once made its home largely cleared. It continues to build its cup-shaped, double-layered nests in secondary forests and spend its days foraging for insects and fruits. As there are relatively few birds around, its role as a seed disperser has taken on an oversized importance in the health of the

ecosystem. With the recent naming of the islands as a World Heritage Site, the bird's future is looking brighter. But limited as it is to three islands, populations remain vulnerable.

As we see it, we can help make the world a better place. Raising awareness of endangered species is just one of the ways we at Canon are taking action—for the good of the planet we call home. Visit canon.com/environment to learn more.



FRITZ HOFFMANN

After a six-hour sledding stint across Greenland's packed snow and ice, patroller Jesper Olsen checks his dogs, one by one, for any injuries. Story on [page 82](#).

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Twins could unlock the secret to how genes and the environment interact to make us who we are.

By Peter Miller

Photographs by Jodi Cobb and Martin Schoeller

66 **Panama's Big Dig**

At an ancient cemetery, gold is surfacing so fast the archaeologist is tempted to yell, Stop, stop!

By A. R. Williams Photographs by David Coventry

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It's 25° below zero. The dogs are unruly. Polar bears lurk. Pay is low. Yet Danes proudly serve.

By Michael Finkel Photographs by Fritz Hoffmann

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"One less land mine, one less child without a leg." Cambodia recovers from the scourge of mines.

By Mark Jenkins

Photographs by Lynn Johnson

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Africa's Afar depression has swallowed camels, spit up a lava lake, and created precious salt.

By Virginia Morell Photographs by George Steinmetz

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Hype brought a flood of Montana homesteaders. Their descendants still struggle with tough terrain.

By David Quammen Photographs by William Albert Allard

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A Mole's Sixth Digit ▶
The mammal's pseud thumb is a boon for burrowing.

Tsunami Debris
It's floating to North America.

Unshrunk Head ▶
For the first time, features have been reconstructed.

Goat Mowers
Got weeds? Call in a herd.

Paging Dr. Panda
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Drilling Deep
Scientists aim to unearth green rock that could tell how the planet formed.

Shaved Ice
A robotic submarine measures the melting of Antarctic glacier bottoms.

Bacteria Save Murals
Microbes help restore frescoes.

Mimicking Sharkskin ▶
Medical devices and paint take a lesson from the overlapping scales.



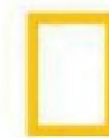
E-GEOGRAPHIC

Here are the coolest extras in our electronic editions.

Seeing Double
Go behind the scenes of our twins cover shoot.
ngm.com + iPad

Dogsledder Diaries
Read the journals of Denmark's patrollers, who brave temps of 25° below and polar bears, on their Greenland mission.
ngm.com + iPad

Montana Memories
Photographer William Albert Allard reflects on his Big Sky portfolio.
ngm.com + iPad



On the Cover
Identical twins Katie (at left) and Sarah Parks, age ten, have their differences. Sarah, the more talkative of the two, was diagnosed with type 1 diabetes at age three. Quieter Katie does not have the disease, which has a genetic component as well as environmental triggers.
Photo by Martin Schoeller

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- Flashback**

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Hot Spot

The “hell-hole of creation” was how Ludovico Mariano Nesbitt described northern Ethiopia’s Afar depression in 1928. Nesbitt was the first European to explore this forbidding landscape and return alive. Three previous expeditions had ended in failure, and it is no mystery why. The Afar is one of the hottest places on Earth, a raw terrain of erupting volcanoes, a boiling lake of lava, and scalding springs. The Afar people who inhabit it are not known for their hospitality. Inviting, it is not—unless you are photographer George Steinmetz. Despite the hardships, he was drawn to the Afar because, as you’ll see in this month’s issue, extraordinary photos can be made there.

Another draw was the edgy, you’re-on-your-own potential for adventure. “One of the wonderful things about Africa,” George says, “is that there usually are no rules or people to enforce them. When we arrived at an erupting caldera, there was nobody to tell us if the lava was going up or down or prone to collapse. Going to the lava-lake rim for a wide-angle photo was like walking the plank, surrounded by noxious volcanic gases that turn the moisture in your nose into sulfuric acid. I wanted to shoot the lake from my paraglider but realized there was no place to land without getting shredded on the sharp, unstable terrain. I have a firm rule to never fly over something without a safe place to glide to in case the motor quits.

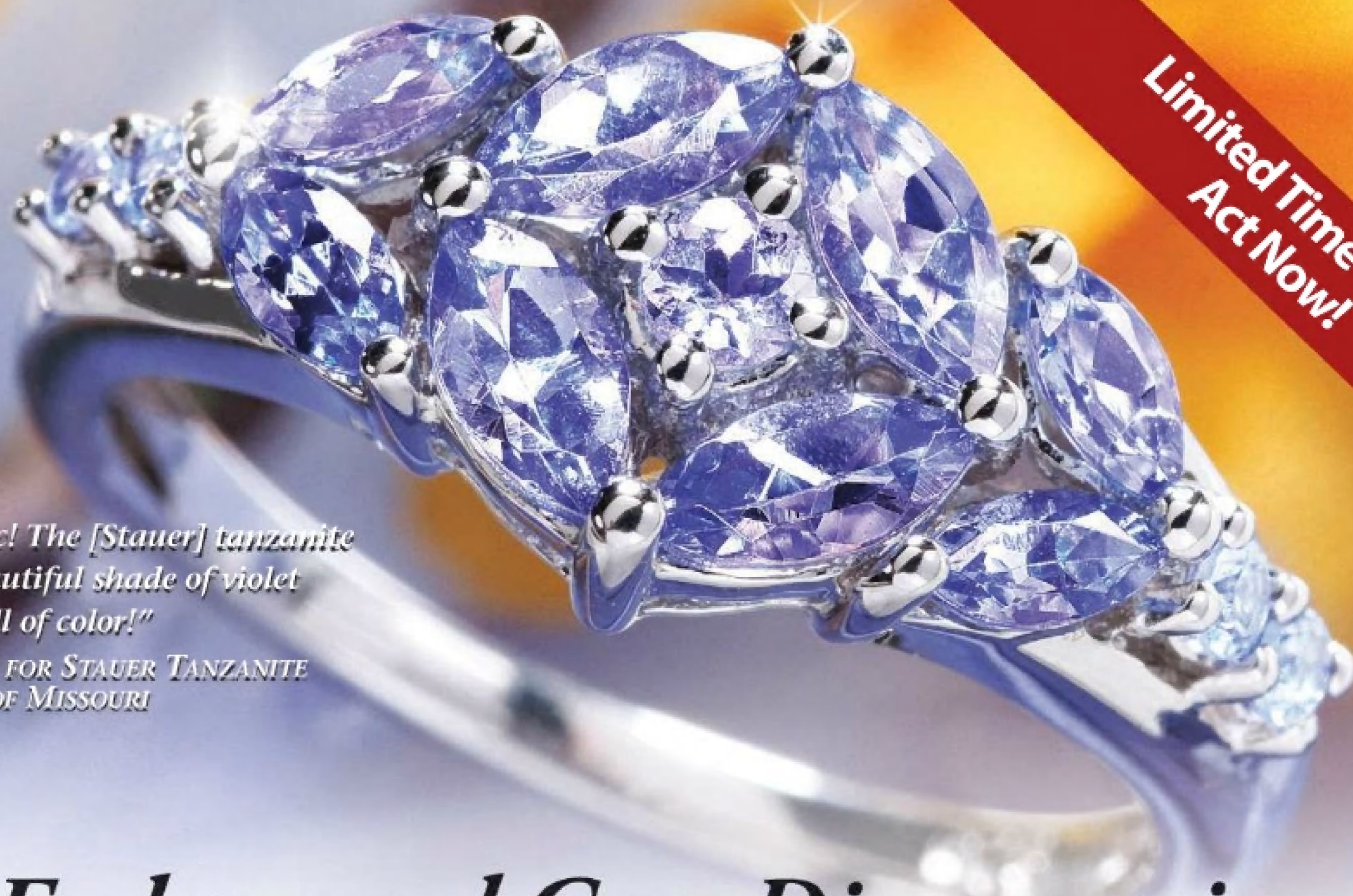
“The next flight I made, at Lake Afrera, my motor did just that when my fuel hose broke. There may be no rules in Africa,” says George, “but it made me glad to live by my own.”

“Going to the lava-lake rim was like walking the plank.”



As George Steinmetz soars over Lake Assal in Africa’s Afar region, the shadow of his paraglider appears as a dark crescent on the sands below.

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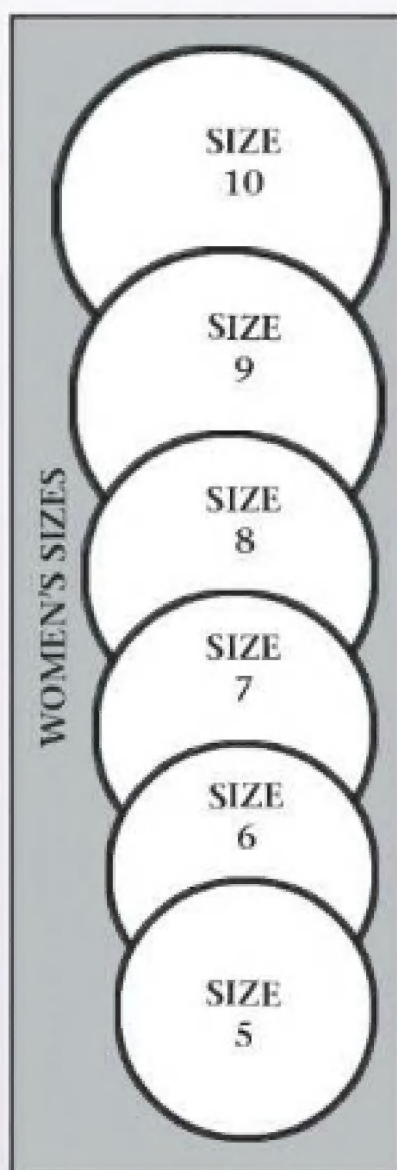
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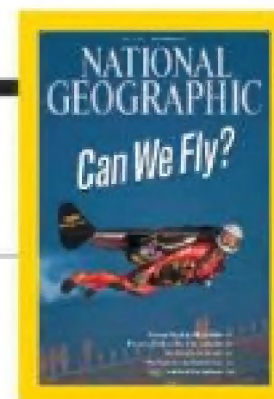
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Brazil's Machisma

The pictures say it all: the side effects of sexual empowerment. The formerly weaker sex is now the stronger and chafes in militant distrust, indignation, and rebellion against men, the church, and their past understandings of God.

- ▶ The sad irony, of course, is that the real determiners aren't even the women themselves. Riches and glamour are the new despots, not ancestral values and gentle reason.

DAVID RUDMIN
Harrisonburg, Virginia

National Geographic's perspective about population problems in Brazil is only partially true. Human progress, including economic progress, is not a product of a few decades of girls going to school or watching *telenovelas* and thinking of their own economic well-being.

ANGELO BERTOLO
Pordenone, Italy

While the demographic change in Brazil is complicated, the article seemed to emphasize one aspect of this transformation—the abandonment of observant Roman Catholicism.

The author intimated this as a positive that liberated women from an oppressive patriarchal system. Rather than this subtle Catholic bashing, a more balanced approach would have been appreciated.

KARL MILLER
Coral Springs, Florida

Race to the South Pole

The author's description of Amundsen's tactic of eating his own sledge dogs while en route to the South Pole as "troubling" reeks of bias. Everything about Amundsen's use of dogs was prudent and wise. He first ate

dogs that were struggling to keep up or that had already died. Scott's expedition refused to kill and eat dogs. They were starving when they died 11 miles from One Ton Depot. We should celebrate Amundsen for completing one of the great feats in exploration while suffering no loss of human life instead of viewing his tactics in the light of 21st-century devotion to our pets (read dogs) and dietary taboos.

TROY CARLSON
Houston, Texas

Orphans No More

The plight of the elephants reminded me of a quote by Mark Twain: "The fact that man knows right from wrong proves his *intellectual* superiority to the other creatures; but the fact that he can *do* wrong proves his *moral* inferiority to any creature that *cannot*."

JOE FRASSETTO
Whitehall, Pennsylvania

Corrections

SEPTEMBER 2011: IF WE ONLY HAD WINGS
Page 72: The correct credit for the photo at right is U.S. Navy/Getty Images.

FEEDBACK

Many readers wrote in about our feature on orphaned elephants—and asked how they could help. But Linda Ryan of Aylett, Virginia, already had the answer:



For more information go to sheldrickwildlifetrust.org.

"The little elephant in the orange raincoat is my baby, and I love her.

The David Sheldrick Wildlife Trust does wonderful work with these beautiful creatures, and I am so proud to be just one of the people who foster an elephant there."

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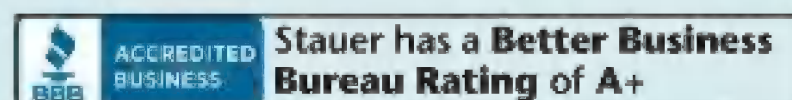
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THIS MONTH

The Dog Whisperer

In season eight of this hit series Cesar Millan, famous for his ability to reform unruly canines, takes on another round of dogs—and occasionally, their owners too.



Display screens fill the National Security Operations Center at NSA headquarters in Maryland.

INSIDE THE NSA Shrouded in mystery and for decades not even acknowledged by the United States government, the National Security Agency (NSA) has kept out of the

NATIONAL GEOGRAPHIC CHANNEL

public eye—until now. Watch as its doors are opened with cameras rolling, taking viewers into secret operations rooms and classified

warehouses. Why allow access now? The agency is hoping transparency will help destigmatize what it does. This hour-long National Geographic Channel special taps into it all, from how spy missions are launched to what pizza boxes have to do with top secret information.

For listings go to natgeotv.com and natgeowild.com.

10,000 Strong

Over the past 122 years National Geographic has supported research by scientists and explorers from 111 countries, including oceanographer Jacques-Yves Cousteau, polar explorer Robert E. Peary, and primatologist Jane Goodall. Some 40 percent of all grant recipients are international, and a new program geared toward northern European scientists means this percentage will rise. Although the earliest Society grantees explored for exploration's sake, many today look for ways humanity can improve its role in the natural world.



Founded in 1888, the National Geographic Society has added to our knowledge of earth, sea, and sky by supporting more than 10,000 explorations and research projects. Readers' membership dues make this support possible.



1st Grant

Israel Cook Russell

Year 1890

Location *United States*

Project *Explore and map 18,008-foot Mount St. Elias, the second highest peak in the United States. Alaska's Russell Fjord is named for him.*



10,000th Grant

Krithi Karanth

Year 2011

Location *India*

Project *Assess and help mitigate the effects of human-wildlife conflict on farmers, livestock, and crops.*

VISIONS

A man in traditional Spanish attire, including a white shirt, dark trousers, and a red headscarf, stands in profile against a textured, light-brown wall. He is holding a thick, coiled rope. To his right, a mule is visible, heavily decorated with garlands of red and yellow fruit. The scene is set in a dusty, outdoor arena.

Spain

At the Feria del Caballo festival in Jerez de la Frontera, an assistant to a *rejoneador*, or horseback bullfighter, stands in the arena wings with mules used to remove felled bulls. The mules are festooned in traditional Spanish colors.

PHOTO: EMILIO MORENATTI, AP IMAGES







Thailand

Stretching across a temple plaza, seemingly into the infinite, thousands of robed monks are ordained at a ceremony on the Buddhist holy day of Magha Puja. The holiday celebrates a key sermon and a gathering of monks during Buddha's lifetime.

PHOTO: LUKE DUGGLEBY, REDUX

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Indonesia

A flurry of filaments helps camouflage the striated frogfish, a bottom-dwelling predator often found in warm, weedy waters. Like its anglerfish relatives, it also employs a dangling lure to seduce fish and other prey into its lair—and gaping mouth.

PHOTO: DANIEL SELMECZI,
STEVE BLOOM IMAGES



READERS' CHOICE Piper Mackay
Long Beach, California

Mackay took this shot of a mother cheetah and her last cub—two others had just been lost to predators—in Kenya's Masai Mara National Reserve. "It shows the commonality of what all mothers feel toward caring for and protecting their children," she says.

EDITORS' CHOICE Nikzad Shahidian
Karaj, Iran

On his way home from the gym one day, the 29-year-old Shahidian saw a man colorfully painting, and carefully straddling, Azadegan Bridge. "He was a wonderful guy," reports Shahidian. "It's unfortunate that most Iranian workers don't have any safety equipment."

EDITORS' CHOICE David Lynch
Dublin, Ireland

"I went to Madrid for an Easter break," says Lynch, 41, "to get photos of Spain's famously stunning holiday parades." Rain canceled the parades and doused those plans. "But when I happened upon a girl in a newspaper dress," he adds, "it made the whole trip worthwhile."

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Near Cancún, Mexico, the coral-spiked statue “Man on Fire” symbolizes our lack of environmental awareness.

Undersea Icons Submerged in transparent ocean waters, my life-size statues act as tropical reefs. At first they look like ruins from an ancient civilization. But look closely. They’re based on real people performing contemporary acts, cast from coral-friendly, pH-neutral marine concrete. Why do I create them? To show what a sustainable, symbiotic relationship with nature might look like.

Five years ago in Grenada, West Indies, my training in sculpture, diving, set design, and photography converged. I realized that underwater statues might be an artistic way to help revive one bay’s ecosystem. After the government agreed, the scale and my ambition grew. I’ve since sunk hundreds of works and shot the results.

First I sketch a statue, then research how best to construct, transport, and install it using cranes and a crew. Once it’s finally in place, up to six months later, I get to photograph it—that’s the fun part. But it’s also a challenge. Salt water alters shapes; weather and light are fickle. So I have to really focus on the opportunity at hand.

Snorkelers, scuba divers, and tourists in glass-bottom boats all see my work now. I hope they enjoy it but also appreciate where it’s located—at a vital intersection of art, science, and the environment.

THE PHOTOGRAPHER

Jason deCaires Taylor is based in Mexico. See more of his work at underwatersculpture.com.



TK ASIAN ANTIQUITIES



Dali Dreamstone, "Grandeur and Innocence" | I.D.D.A. Awarded "Diamond" Ranking

Collected from the Dian Cang Mountain in the city of Dali of Yunnan Province in August 2007
by Master Selector Wang Qing Yuan.

Date: 21st Century | Medium: Marble | Image Size: 10 1/4" Diameter

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I sank this sculpture—complete with holes in the TV set for fish—off the Cancún coast and titled it “Inertia.” Why? Because the unsustainability of our lifestyles is scientifically proven, yet we remain oblivious.



This statue sits 16 feet deep in waters off Grenada’s Molinière Point. Sponges colonized the side that faces a steady nutrient flow from the open ocean. This is one of the few shots for which I used lighting.



Not seen for years in Cancún waters, a gray angelfish swims past one of the 400 figures in my 4,520-square-foot installation called “The Silent Evolution.” I hope to add 200 sculptures to the site this year.



NOW



Most moles have an extra “thumb,” seen here in a Townsend’s mole’s skeletal paw.

Digit No.6

We like to boast about our opposable thumbs, but the humble mole has a little extra something too—a sixth “digit,” or pseudothumb, to bolster its burrowing prowess.

The sprouting of extra digits, aka polydactyly, occurs occasionally among five-fingered mammals. But it’s the norm for most species of mole, which put their expanded paws to work in the soils of Europe, Asia, and North America. To better understand the phenomenon, a team led by University of Zurich paleontologist Marcelo Sánchez dug further last year into the appendage’s embryonic development and molecular nature.

Skeletal studies had shown that the mole’s “thumb” forms from an elongated wristbone. So, unlike true digits, which have multiple parts, the pseudothumb consists of a single, bladelike bone. The new study reveals that it develops later than authentic fingers but shares one genetic marker.

Who else numbers among the six fingered? Giant pandas and, legend has it, England’s Queen Anne Boleyn. —Luna Shyr



Actual size





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Artist depiction

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Prescription Lyrica is not for everyone. Tell your doctor right away about any serious allergic reaction that causes swelling of the face, mouth, lips, gums, tongue, throat or neck or any trouble breathing or that affects your skin. Lyrica may cause suicidal thoughts or actions in a very small number of people. Call your doctor right away if you have new or worsening depression, suicidal thoughts or actions, or unusual changes in mood or behavior. Lyrica may cause swelling of your hands, legs and feet. Some of the most common side effects of Lyrica are dizziness and sleepiness. Do not drive or work with machines until you know how Lyrica affects you. Other common side effects are blurry vision, weight gain, trouble concentrating, dry mouth, and feeling "high." Also, tell your doctor right away about muscle pain along with feeling sick and feverish, or any changes in your eyesight including blurry vision or any skin sores if you have diabetes. You may have a higher chance of swelling, hives or gaining weight if you are also taking certain diabetes or high blood pressure medicines. Do not drink alcohol while taking Lyrica. You may have more dizziness and sleepiness if you take Lyrica with alcohol, narcotic pain medicines, or medicines for anxiety. If you have had a drug or alcohol problem, you may be more likely to misuse Lyrica. Tell your doctor if you are planning to father a child. Talk with your doctor before you stop taking Lyrica or any other prescription medication.

Please see Important Risk Information for Lyrica on the following page.

To learn more visit www.lyrica.com or call toll-free 1-888-9-LYRICA (1-888-959-7422).

You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.FDA.gov/medwatch or call 1-800-FDA-1088.

IMPORTANT FACTS



(LEER-i-kah)

IMPORTANT SAFETY INFORMATION ABOUT LYRICA

LYRICA may cause serious, even life threatening, allergic reactions. Stop taking LYRICA and call your doctor right away if you have any signs of a serious allergic reaction:

- Swelling of your face, mouth, lips, gums, tongue, throat or neck
- Have any trouble breathing
- Rash, hives (raised bumps) or blisters

Like other antiepileptic drugs, LYRICA may cause suicidal thoughts or actions in a very small number of people, about 1 in 500.

Call your doctor right away if you have any symptoms, especially if they are new, worse or worry you, including:

- New or worsening depression
- Suicidal thoughts or actions
- Unusual changes in mood or behavior

Do not stop LYRICA without first talking with your doctor.

LYRICA may cause swelling of your hands, legs and feet.

This swelling can be a serious problem with people with heart problems.

LYRICA may cause dizziness or sleepiness.

Do not drive a car, work with machines, or do other dangerous things until you know how LYRICA affects you. Ask your doctor when it is okay to do these things.

ABOUT LYRICA

LYRICA is a prescription medicine used in adults 18 years and older to treat:

- Pain from damaged nerves that happens with diabetes or that follows healing of shingles
- Partial seizures when taken together with other seizure medicines
- Fibromyalgia (pain all over your body)

Who should NOT take LYRICA:

- Anyone who is allergic to anything in LYRICA

BEFORE STARTING LYRICA

Tell your doctor about all your medical conditions, including if you:

- Have had depression, mood problems or suicidal thoughts or behavior
- Have or had kidney problems or dialysis
- Have heart problems, including heart failure
- Have a bleeding problem or a low blood platelet count
- Have abused prescription medicines, street drugs or alcohol in the past
- Have ever had swelling of your face, mouth, tongue, lips, gums, neck, or throat (angioedema)
- Plan to father a child. It is not known if problems seen in animal studies can happen in humans.
- Are pregnant, plan to become pregnant or are breastfeeding. It is not known if LYRICA will harm your unborn baby.

You and your doctor should decide whether you should take LYRICA or breast-feed, but not both.

Tell your doctor about all your medicines. Include over-the-counter medicines, vitamins, and herbal supplements.

LYRICA and other medicines may affect each other causing side effects. Especially tell your doctor if you take:

- Angiotensin converting enzyme (ACE) inhibitors. You may have a higher chance for swelling and hives.

BEFORE STARTING LYRICA, continued

- Avandia® (rosiglitazone)*, Avandamet® (rosiglitazone and metformin)* or Actos® (pioglitazone)** for diabetes. You may have a higher chance of weight gain or swelling of your hands or feet.
- Narcotic pain medicines (such as oxycodone), tranquilizers or medicines for anxiety (such as lorazepam). You may have a higher chance for dizziness and sleepiness.
- Any medicines that make you sleepy

POSSIBLE SIDE EFFECTS OF LYRICA

LYRICA may cause serious side effects, including:

- See “Important Safety Information About LYRICA.”
- Muscle problems, pain, soreness or weakness along with feeling sick and fever
- Eyesight problems including blurry vision
- Weight gain. Weight gain may affect control of diabetes and can be serious for people with heart problems.
- Feeling “high”

If you have any of these symptoms, tell your doctor right away.

The most common side effects of LYRICA are:

- Dizziness
- Blurry vision
- Weight gain
- Sleepiness
- Trouble concentrating
- Swelling of hands and feet
- Dry mouth

If you have diabetes, you should pay extra attention to your skin while taking LYRICA and tell your doctor of any sores or skin problems.

HOW TO TAKE LYRICA

Do:

- Take LYRICA exactly as your doctor tells you. Your doctor will tell you how much to take and when to take it. Take LYRICA at the same times each day.
- Take LYRICA with or without food.

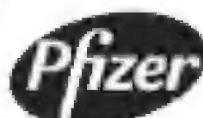
Don't:

- Drive a car or use machines if you feel dizzy or sleepy while taking LYRICA.
- Drink alcohol or use other medicines that make you sleepy while taking LYRICA.
- Change the dose or stop LYRICA suddenly. You may have headaches, nausea, diarrhea, or trouble sleeping if you stop taking LYRICA suddenly.
- Start any new medicines without first talking to your doctor.

NEED MORE INFORMATION?

- Ask your doctor or pharmacist. This is only a brief summary of important information.
- Go to www.lyrica.com or call 1-866-459-7422 (1-866-4LYRICA).

Uninsured? Need help paying for Pfizer medicines? Pfizer has programs that can help. Call 1-866-706-2400 or visit www.PfizerHelpfulAnswers.com.



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Debris floating on the sea surface, tons per square mile

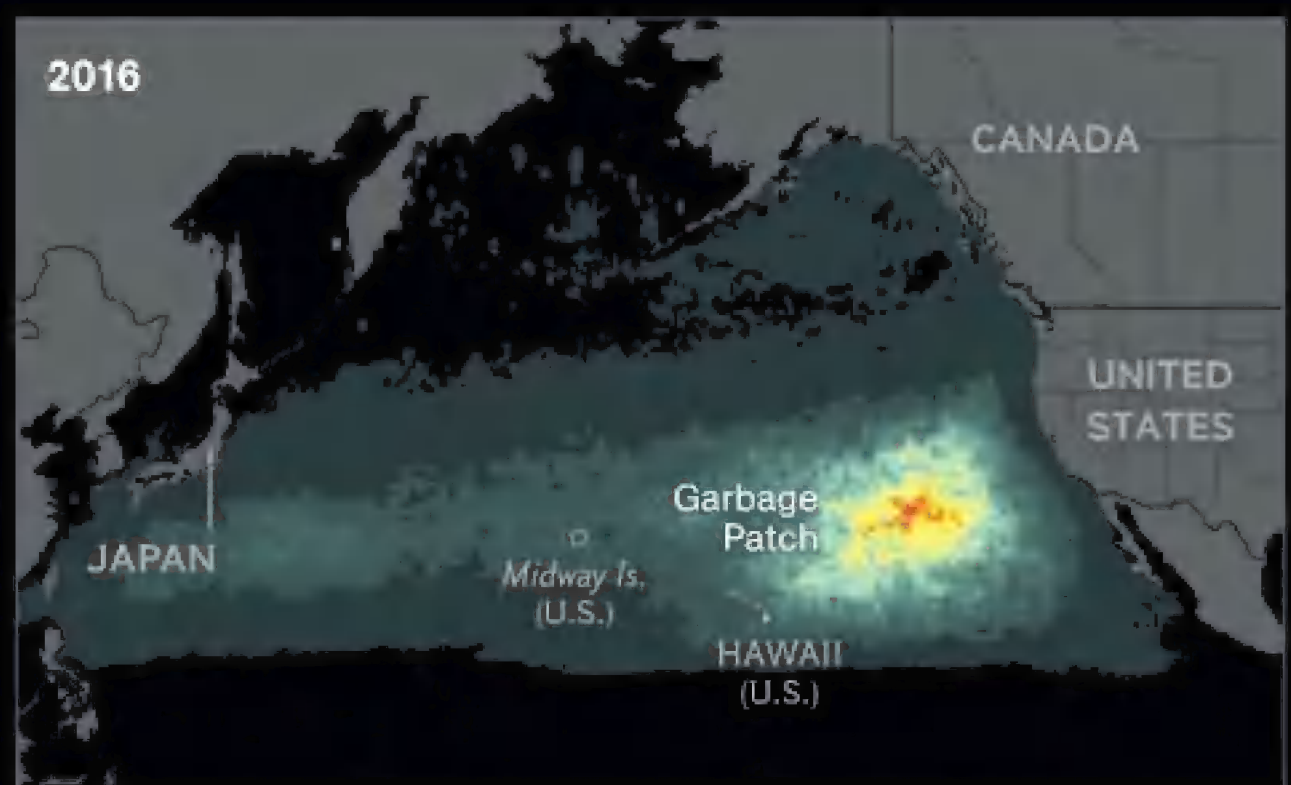
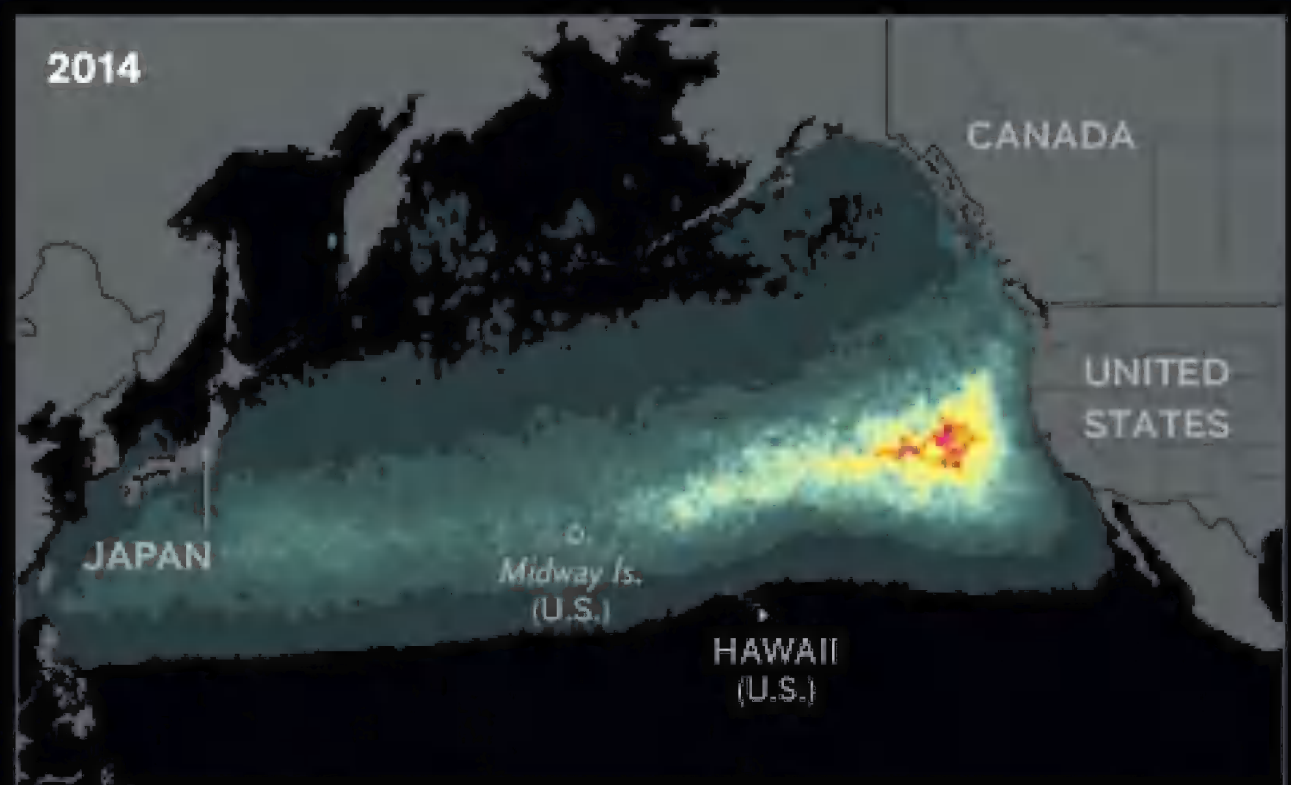
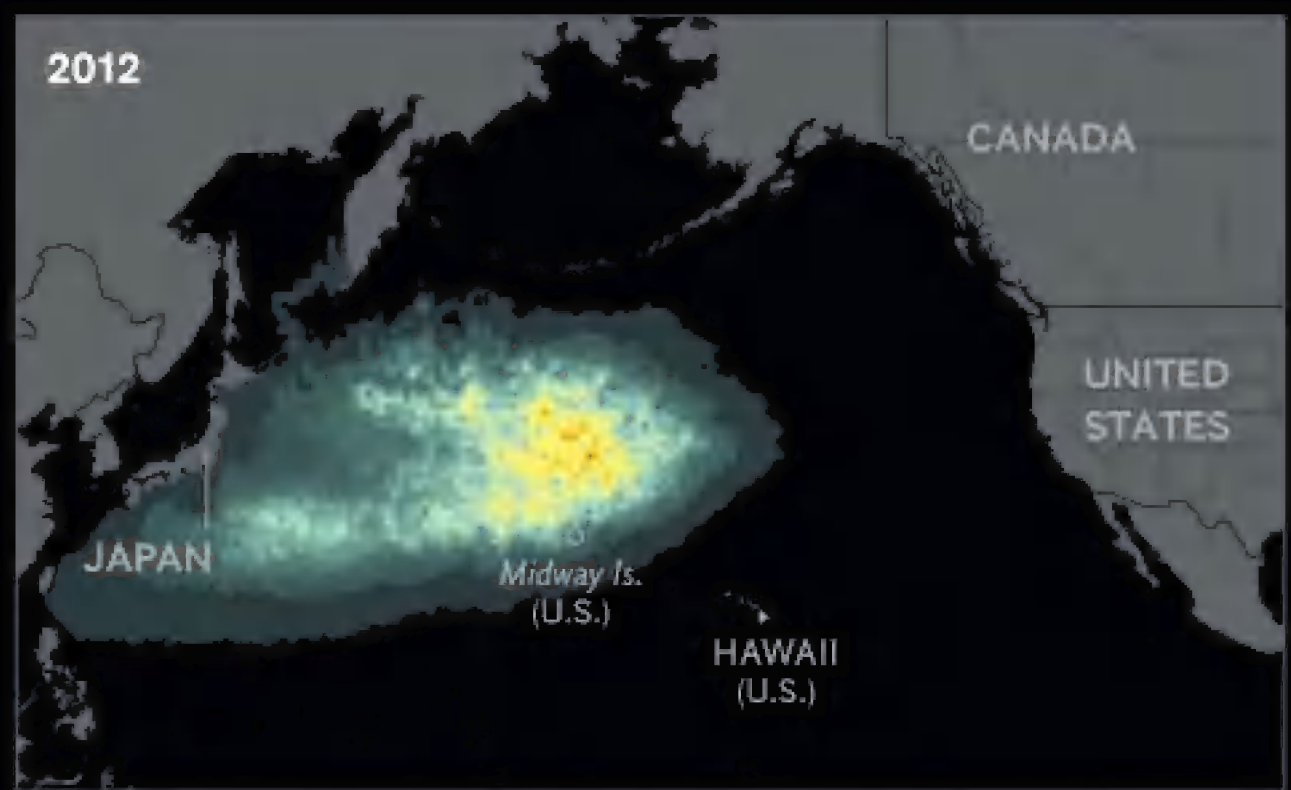
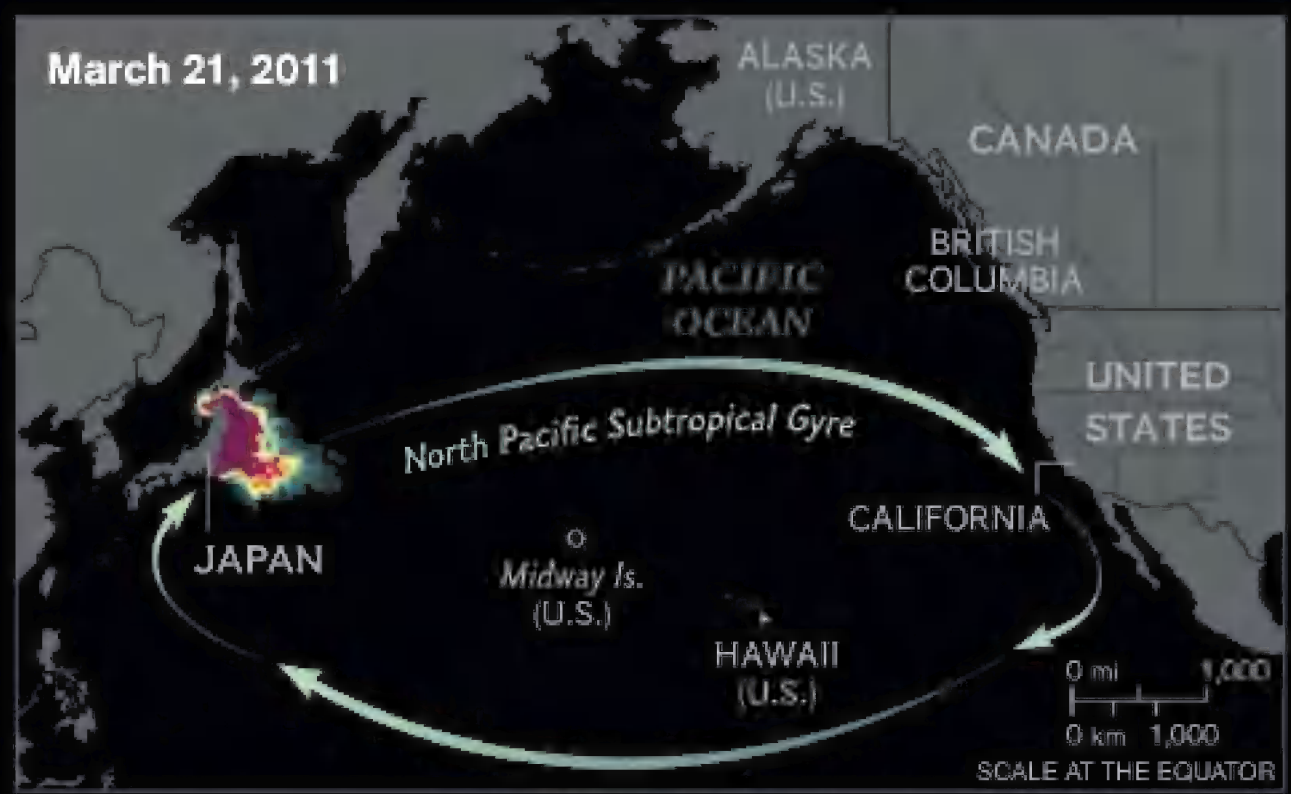


Tsunami Debris Path

The magnitude 9 earthquake that rocked Japan last March and triggered a tsunami killed more than 15,000 and washed millions of tons of debris—cars, houses, chunks of whole towns—into the ocean. Since then the grim flotsam has been heading east through fisheries, shipping lanes, and natural habitats.

To figure out when and where it will go, Nikolai Maximenko and Jan Hafner of the International Pacific Research Center are using a new ocean-current model (right) based on satellite data and the drifting behavior of 15,000 scientific buoys. They predict the debris field will reach the Midway Islands one year after the disaster. By the second anniversary it will hit Hawaii. In three years the North American coast will see it. Finally, five years after it was loosed, the debris will join the infamous North Pacific Garbage Patch.

Oceanographers Curt Ebbesmeyer and Jim Ingraham favor an older predictive model based more on wind effects. They say objects poking out of the water—car tires, TV sets, plastic toys—could reach California and British Columbia this year. By 2014, says Ebbesmeyer solemnly, so could shoe-encased feet. His message to beachcombers: “Be respectful.” —Jeremy Berlin



This five-year projection shows how debris from Japan’s 2011 earthquake and tsunami disaster is likely to spread via the North Pacific Subtropical Gyre, a clockwise spiral of currents.

NOW



Actual size

Long hair and earrings of toucan feathers are typical of Shuar heads. The thick, leathery skin holds the shape of the shrunken head, which is hollow. The hair retains its original length.

For the first time, a portrait emerges from a South American shrunken head.

IN 1923 THIS TROPHY HEAD (left) arrived at what is now the McManus Museum in Dundee, Scotland. Was it a man or a monkey? Was it authentic? And most intriguing, what did the original face look like? The artifact was



thought to come from the western Amazon, home to the Shuar people. Also called Jivaro in early descriptions, they believed a slain enemy harbored an avenging spirit that could be overcome only by shrinking the dead person's

head and holding related ceremonies. As more Europeans entered the region in the late 1800s, such heads, or tsantsas, became popular souvenirs. Fakes soon appeared, some made from animals.

To solve the mysteries, University of Dundee forensic art student Tobias Houlton launched a modern investigation. Examining the hair and scalp revealed that the head was human. Details such as the distended lips and the dark, polished skin convinced him that this was a true Shuar creation. He then experimented on pigs, whose skin consistency resembles that of humans, to test the physical effects of head shrinking. Following the steps (right) documented by a collector who had lived with the Shuar, he found that cartilage resists shrinkage, resulting in the snub-nosed profile typical of tsantsas.

With the assumption that the head belonged to a young warrior, Houlton reconstructed his features (above) using the latest forensic computer tools, as if working on a police case. No other tsantsa has been brought back to life like this, so the man—whoever he was—has now become the face of a lost tradition. —A. R. Williams

How to Shrink a Head

During a raid a victor would decapitate his fallen enemy. He then made one cut and peeled the skin from the skull, producing a pliable mask of face and hair.

1 Heat Treatment

After the skin soaked in hot water, residual fat was scraped off. The cut was sewn to restore the head's shape, and hot stones were dropped into the neck hole.



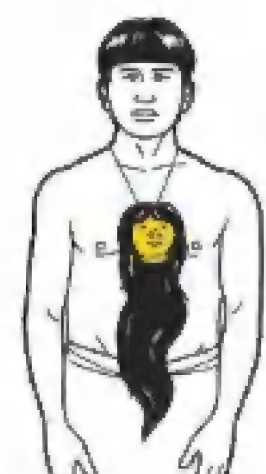
2 Face Work

Hot sand followed the stones, shrinking the head as it dried. The face was smeared with charcoal and ironed smooth with more hot stones.



3 War Trophy

Now the size of a large fist, the head was smoked for preservation. A cord attached at the crown allowed it to be worn as a necklace.



NOW

How long is a day?
It depends on which
planet you're on.

Mercury
58.6



Venus
243



Earth
23.9



Mars
24.6



Jupiter
9.9



Saturn
10.7



Uranus
17.2

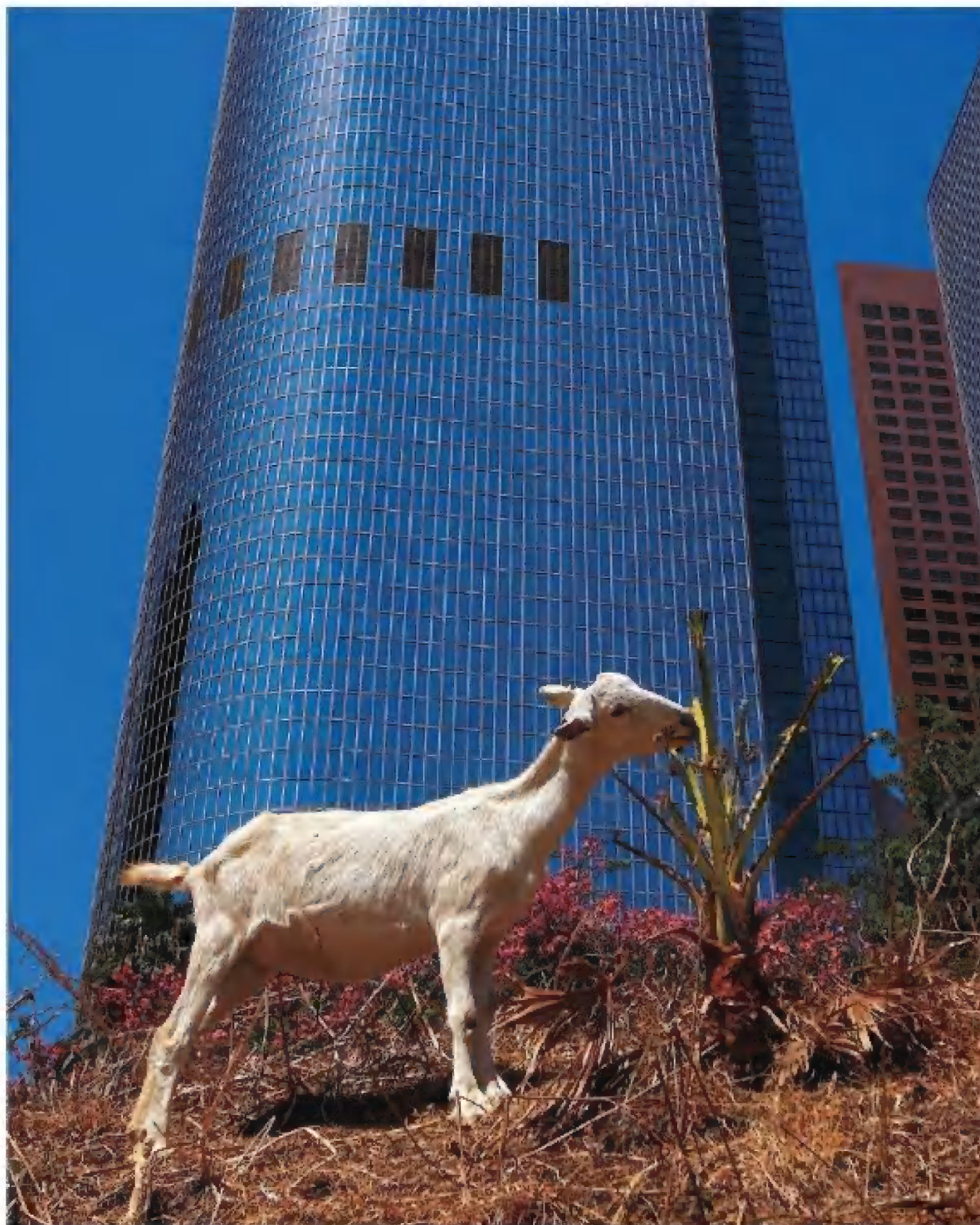


Neptune
16.0



EARTH DAYS

HOURS



A hungry goat helps clear unwanted plants in downtown Los Angeles.

Goat Mowers Goats like to eat poison ivy. And sagebrush. And kudzu and leafy spurge. That's why they're stars of targeted grazing—the use of hungry ruminants to whack undesirable plants, including invasives and the undergrowth that feeds wildfires. The practice is popular in the U.S. as well as in Canada and Australia.

Herds for hire began taking off about a decade ago, says John Walker, a Texas A&M ecosystems professor. Sheep and goats are both employed, but goats win kudos for eclectic appetites, grazing high on hind legs, and sure-footedness on steep slopes. Their flexible lips deftly pluck leaves. Customers include parks, ranches, and homeowners. Goats are fenced and watched by a goatherd or dog, to guard against predators. A herd of a hundred might cost \$200 a day.

But you can't tell them what to eat. Goats "have their list," says An Peischel of Wyoming's Goats Unlimited. First they chow down on their favorite plant, then circle back for the runners-up. —*Marc Silver*

Suiting Up, Panda Style

Forget fashion. At the Wolong Nature Reserve in China's Sichuan Province, donning a giant panda costume is a conservation statement.

Since 2010 scientists there have been stepping into custom-made panda suits (below) to monitor resident bears and perform monthly medical checks on cubs and their mothers. Why dress in disguise? The theory is that the outfit prevents captive-bred pandas from getting too accustomed to seeing or relying on humans.

It's not clear yet whether the technique is effective, as the pandas won't be released into China's mountainous forests for at least a year. So only time will tell if the researchers' little black-and-white lie has been a boon to the endangered species.

—*Catherine Zuckerman*

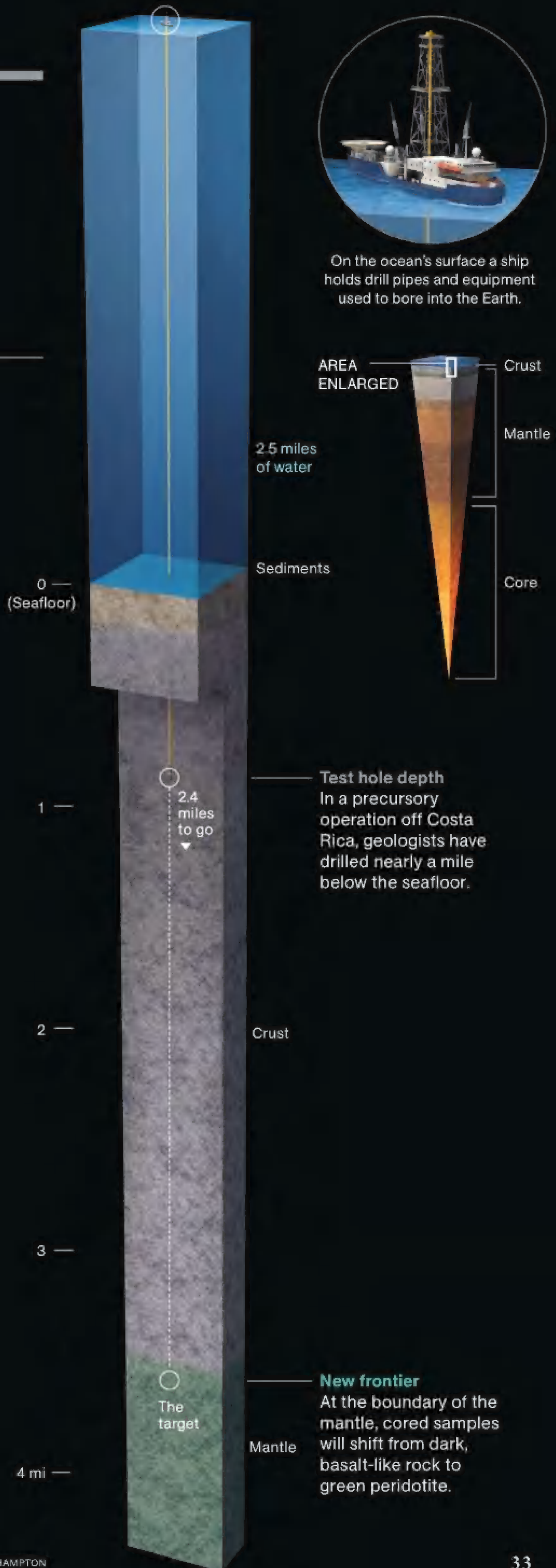


NOW NEXT

Drilling to the Mantle

Deep within the Earth lies lustrous green rock that holds the key to mysteries about the origins of our planet. It's part of a layer—the mantle—that makes up 84 percent of the Earth's volume. Bits of the rock, modified by heat and pressure, are spit from volcanoes and prized in polished form as the gem peridot. But no one has ever laid eyes on fresh mantle peridotite. Now an international team aims to bore through Earth's crust to retrieve the first sample. "Pristine mantle would be a geochemical treasure trove equivalent to the Apollo lunar rocks," says the University of Southampton's Damon Teagle.

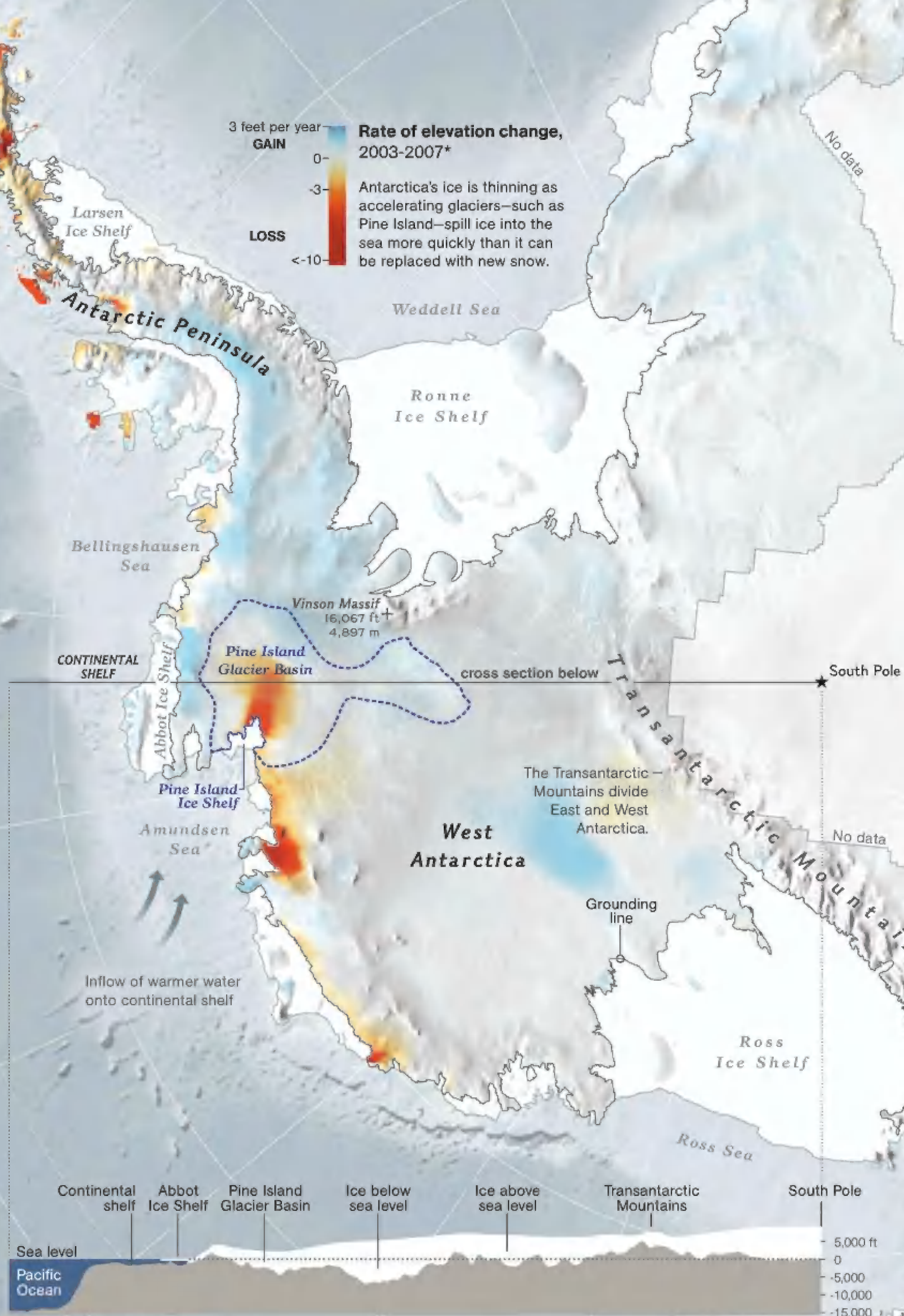
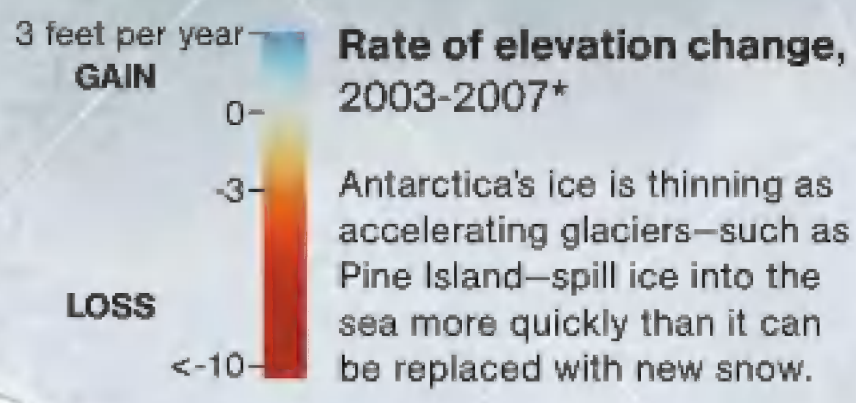
Scientists are scouting spots off Costa Rica, Baja California, and Hawaii for the best site to drill. There sediments are thin, and the mantle is cool enough to core. But the seafloor is some 2.5 miles down, making drilling operations deep even by oil industry standards. Reaching the target distance is now feasible with the Japanese ship *Chikyu*, which can hold more than six miles of drill pipes. And drill bits with tungsten carbide teeth are being refined to tackle ultrahard rocks that have ruined equipment in previous attempts. The big dig's set to start before decade's end. —Juli Berwald



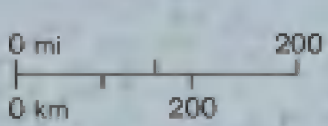
NEXT

ANTARCTIC CIRCLE

30°W 70°S



Below the icy surface This cross section shows that in the Amundsen Sea region, much of the ice slides on a bed that's below sea level, where relatively warm, deep water is contributing to the thinning of ice shelves.

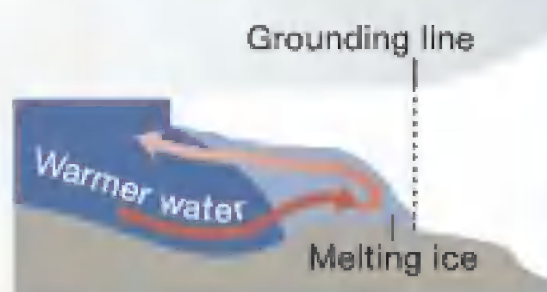


70°S

East
Antarctica



Meltwater erodes channels in a calving ice shelf in West Antarctica.



Oceanic dynamo

Each day eight cubic miles of warm ocean water circulate under the Pine Island Ice Shelf. That water melts and thins the ice from beneath, causing the glacier to slide more quickly into the ocean.



Changing currents

Changes in winds and ocean circulation, possibly due to global climate change, are bringing more warm water into contact with the frozen coasts of West Antarctica.

Antarctica Undercut

Pine Island Glacier in West Antarctica is hemorrhaging ice at an alarming rate. But it's happening far beyond the reach of human eyes—3,000 feet below the ocean's surface, beneath a shelf of floating ice as thick as two Empire State Buildings would be tall.

Autosub3, a robotic submarine, visited this remote spot in 2009. It explored 30 miles under Pine Island's ice shelf, using sonar to map the seafloor below and the ice ceiling above. While the sub worked, the research vessel *Nathaniel B. Palmer* measured a worrying process: Strengthening ocean currents are bringing more deep, warm water into contact with thinning ice, melting 19 cubic miles of the ice shelf's underside in 2009 alone and causing the glacier to flow faster into the ocean. Since 1974 Pine Island has thinned by 230 feet and accelerated by more than 70 percent.

Hundreds of miles of Antarctica's coastline are now subject to the same forces, which are expected to drive the increase in ice loss for decades to come. It's difficult but vital to monitor what's happening to the ice shelf's weak underbelly, says Stanley Jacobs of the Lamont-Doherty Earth Observatory, who led the international expedition along with Adrian Jenkins of the British Antarctic Survey. The information gathered from beneath the world's bottom is essential to making accurate predictions about sea-level rise. —*Douglas Fox*



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NEXT

An adult blue whale's heart is about nine feet wide and weighs around 2,000 pounds.



In a Spanish church a fresco previously cleaned by bacteria gets a touch-up.

Beauty and the Bacteria The 17th-century frescoes in Valencia's Santos Juanes Church cover nearly 13,000 square feet, but much of the surface is in rough shape. The paintings were damaged when the church burned during the Spanish Civil War. Then a restoration effort in the 1960s left glue residue on the art, and nitrates from the droppings of pigeons roosting behind the walls migrated through to the surface, leaving a white buildup.

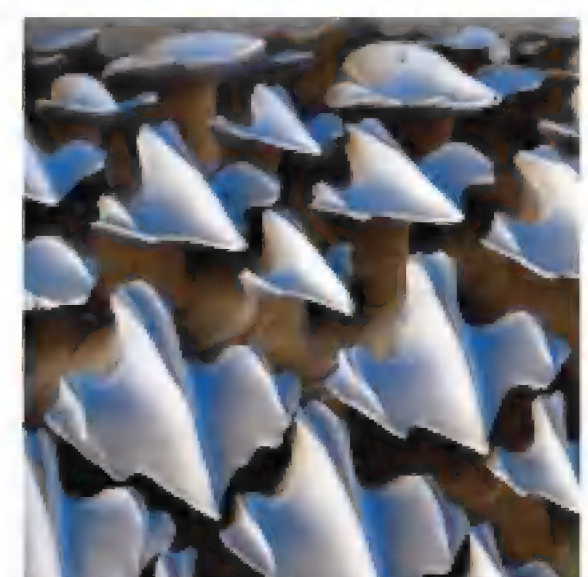
To clean the artworks, scientists and restorers from the Polytechnic University of Valencia used bacteria that were trained in a lab to eat certain types of organic matter. They apply the microbes in a gel, then sponge it away after 90 minutes. In the absence of moisture, the bacteria die. The team learned the technique from a restoration project in Pisa, Italy. Says biologist Pilar Bosch Roig: "It's quick, it's selective, and it's cheaper than traditional ways." —*Murray Carpenter*

Sharks' Skin Suits

Sharks have been models of efficiency for 400 million-plus years, inspiring fear, wonder, and movies. Now a secret to their long success—scaly skin that resists microorganisms and reduces drag—is inspiring biomimetics.

University of Florida engineer Anthony Brennan says all sharks have overlapping scales, or denticles (below), that are too rough for bacteria to colonize. His firm, Sharklet Technologies, mimics the unique pattern to inhibit bacterial growth on medical devices and surfaces.

The pattern is also the basis for a stencil-applied paint from Germany's Fraunhofer research institute. According to engineer Volkmar Stenzel, it may soon help planes and ships save fuel. If development continues swimmingly, the paint could eventually boost wind-turbine efficiency as well. —*Jeremy Berlin*



SPINY DOGFISH SHARK SCALES

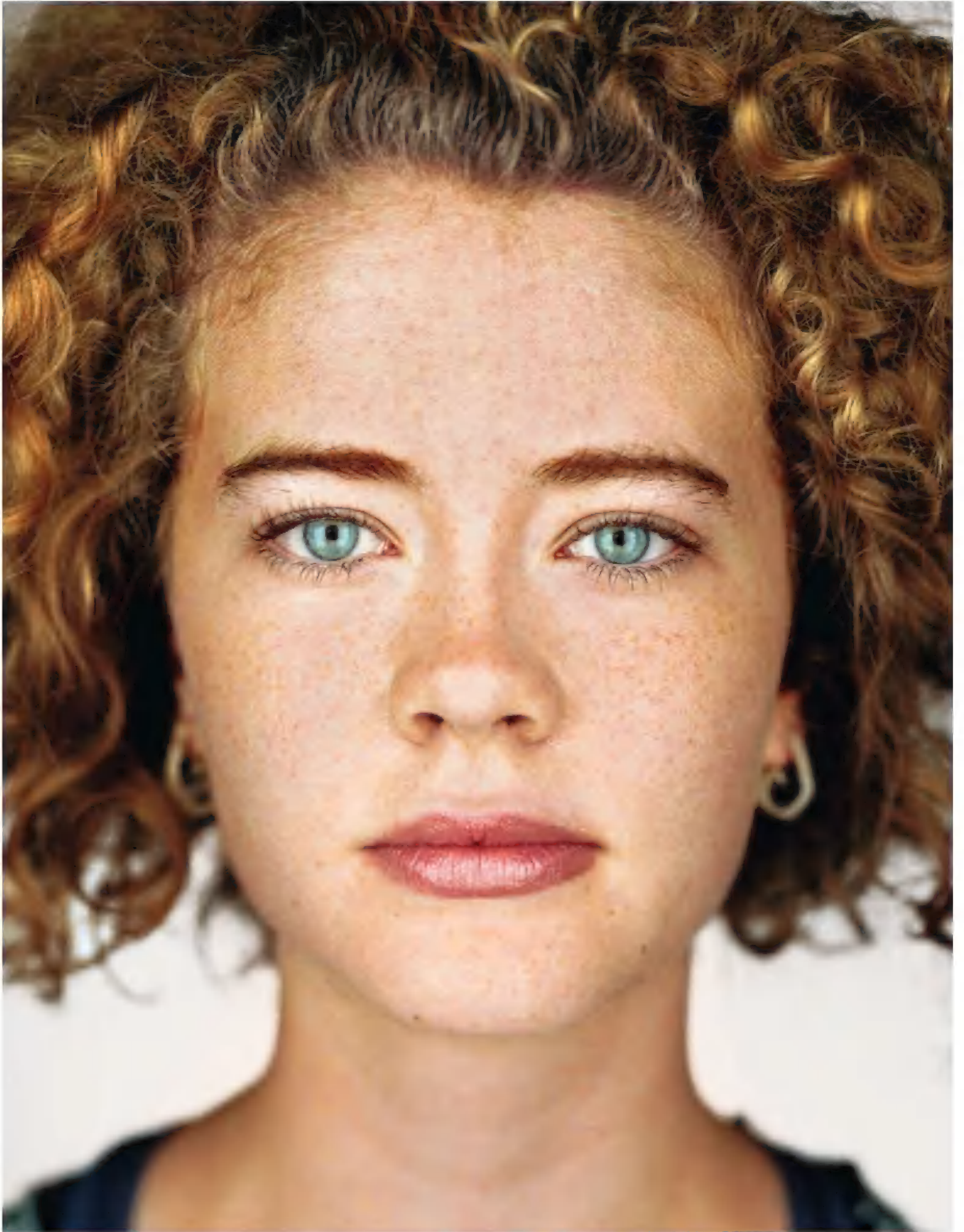
A thing or two...

Six-year-old Johanna Gill puts a protective hand on her sister, Eva. The twins both have mild autism, a disorder linked to genetic inheritance.





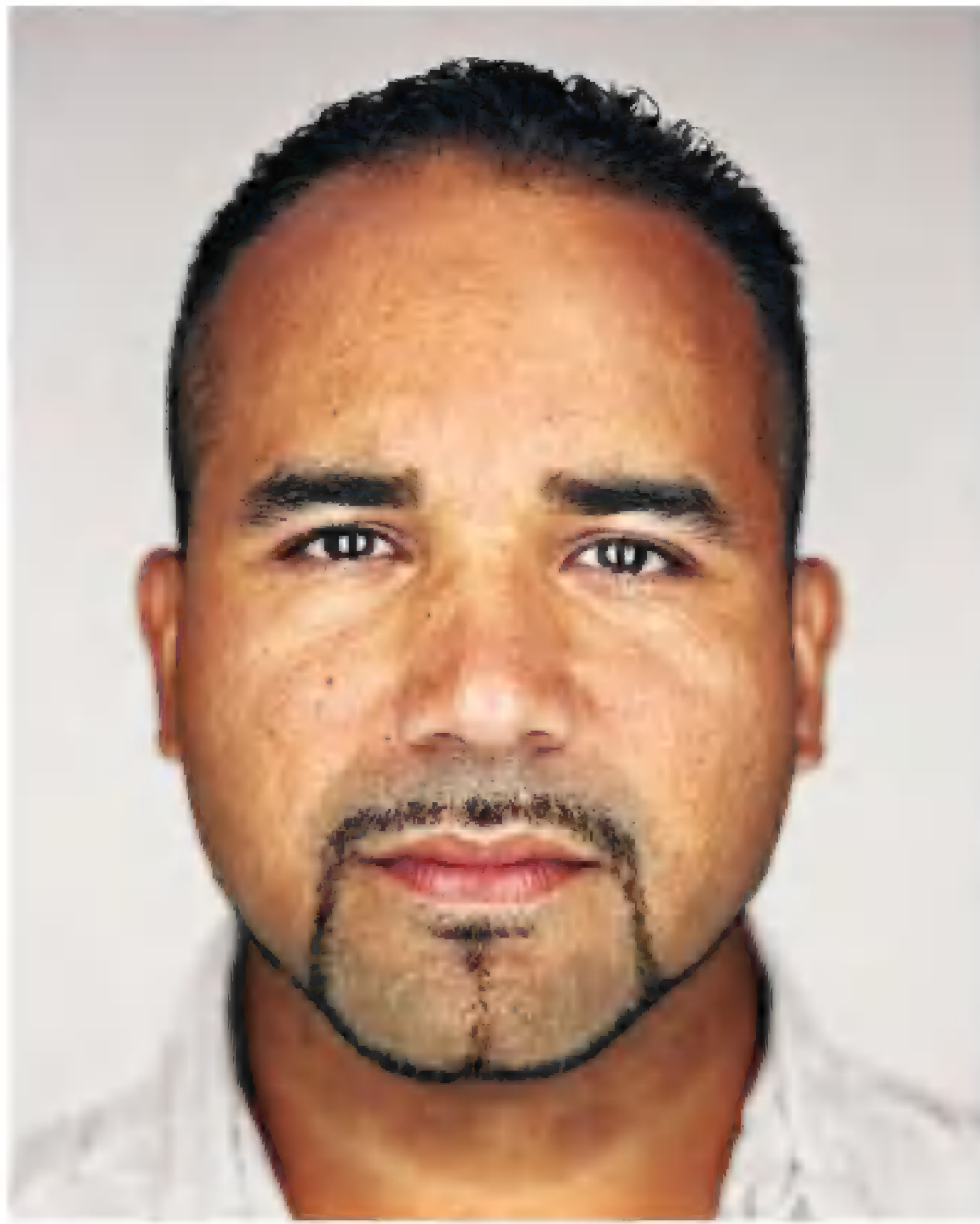
about twins.



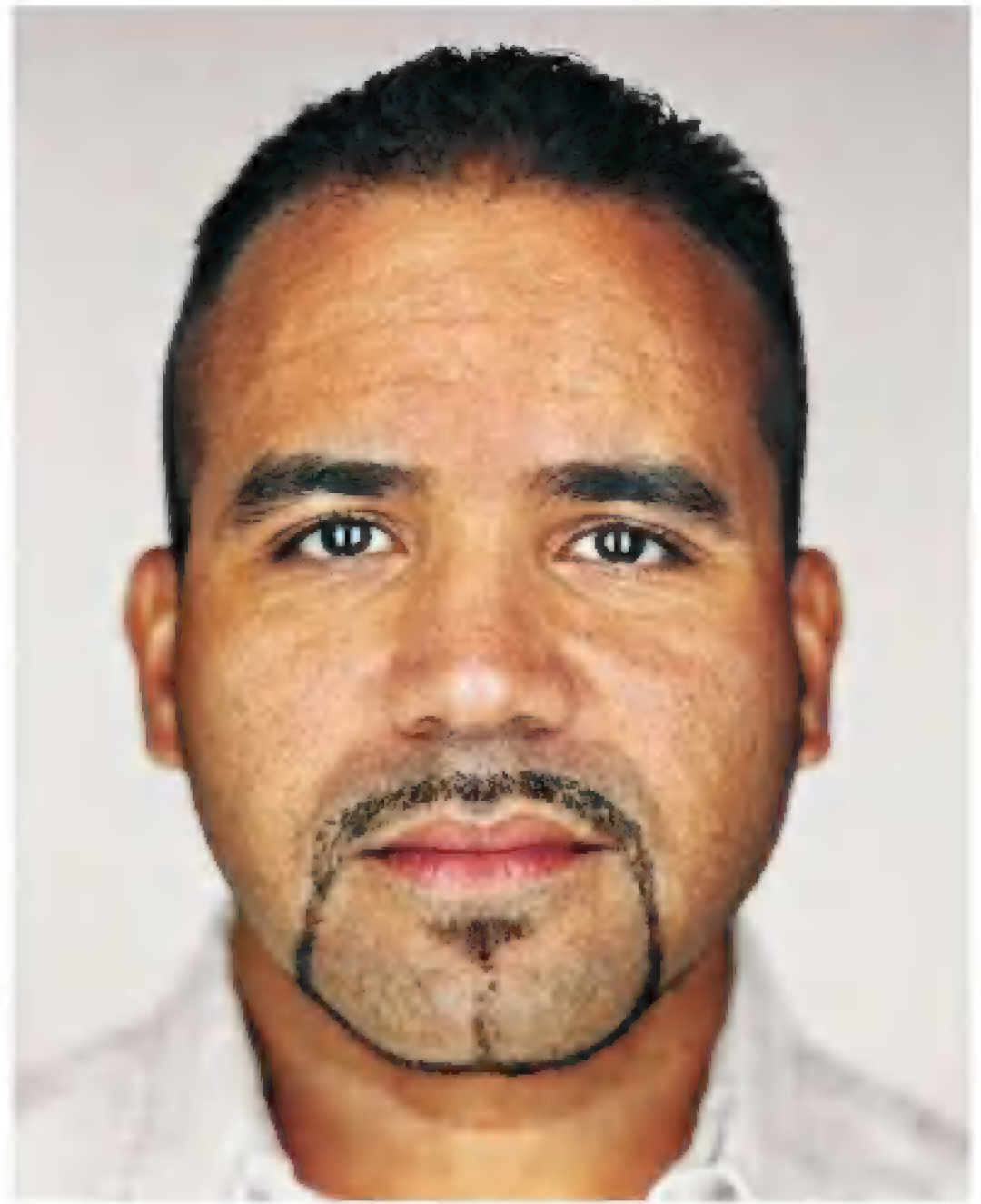
Marta

Emma





Ramon

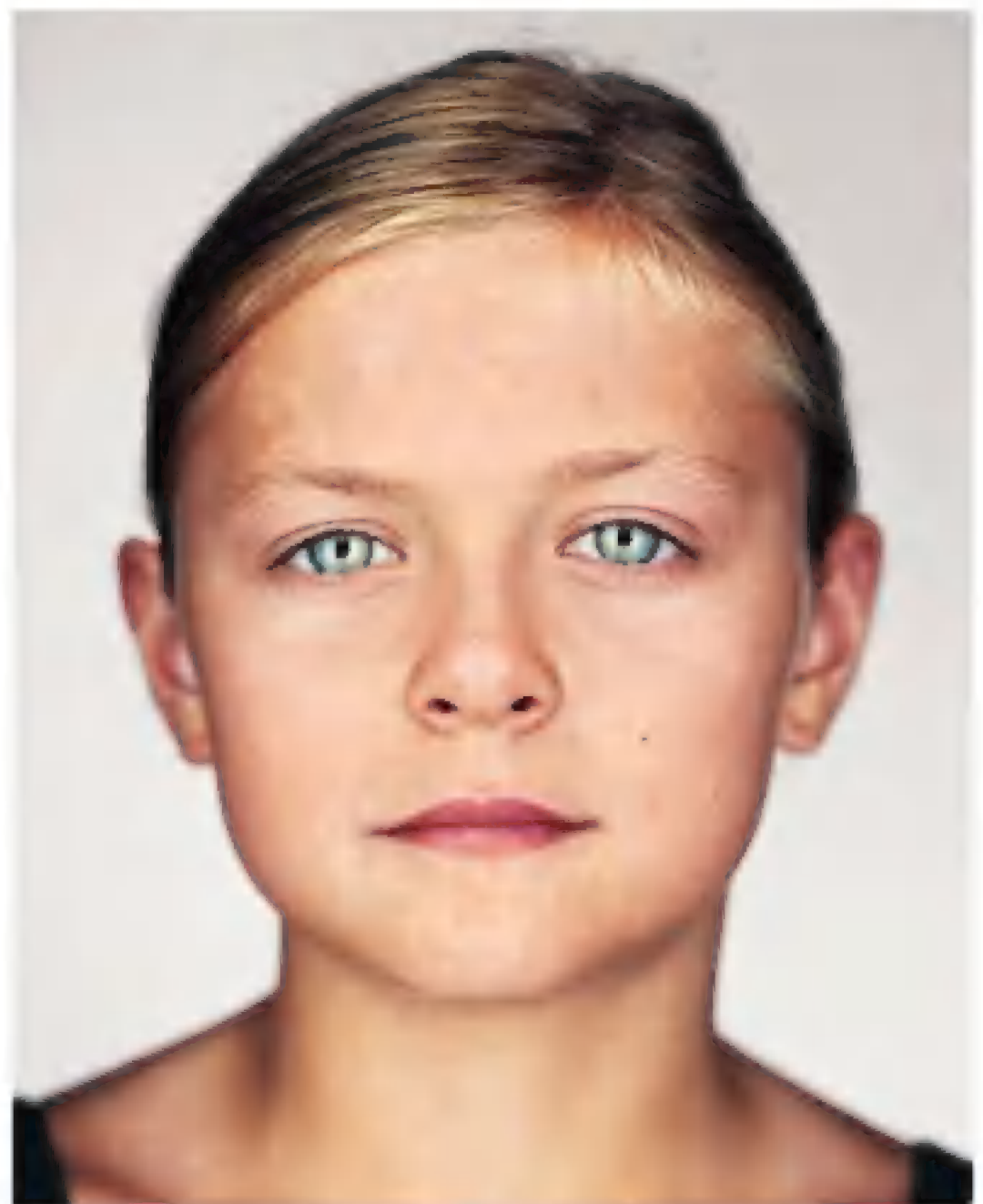


Eurides

They have the same piercing eyes. The same color hair.



Emily



Kate

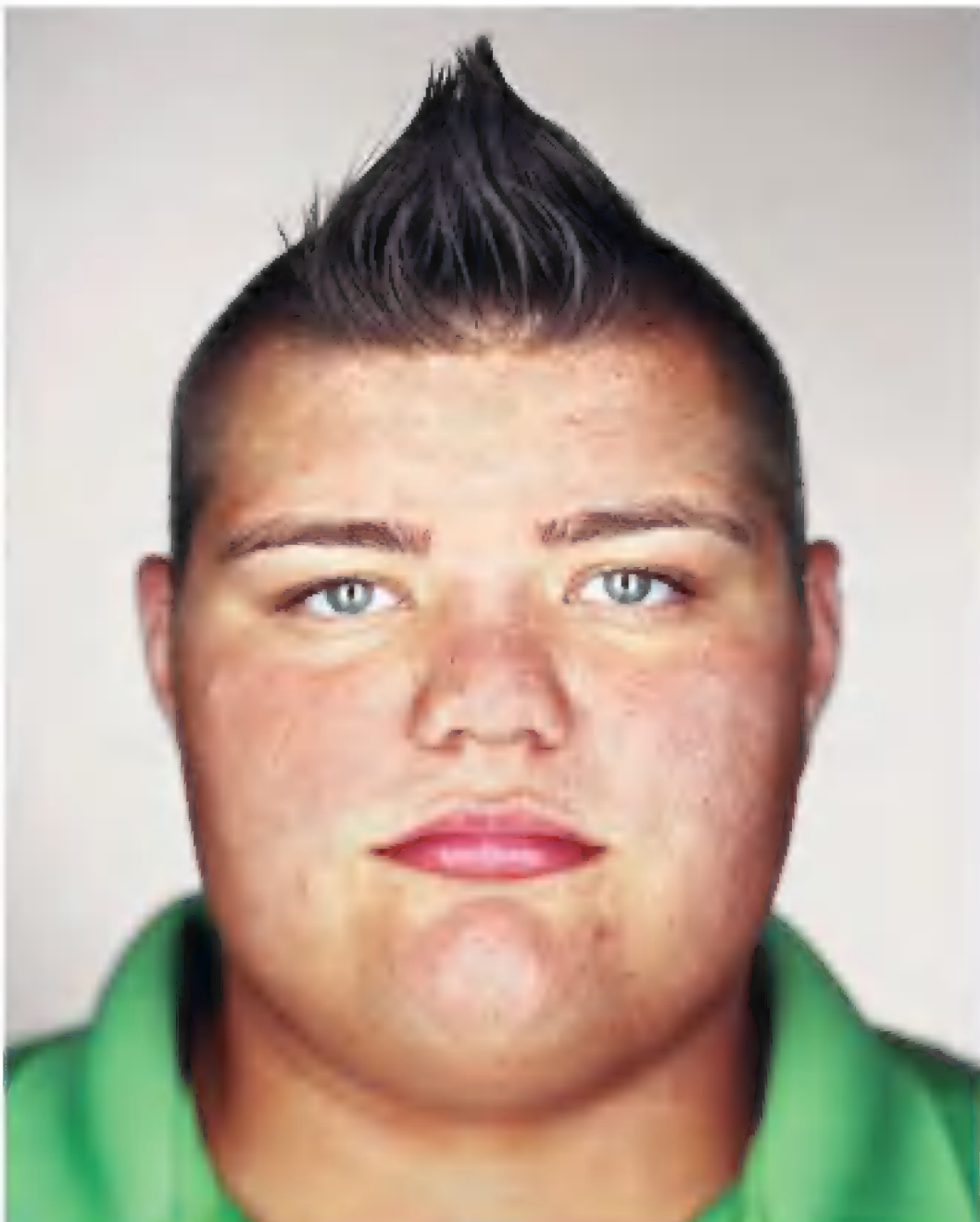


Loretta

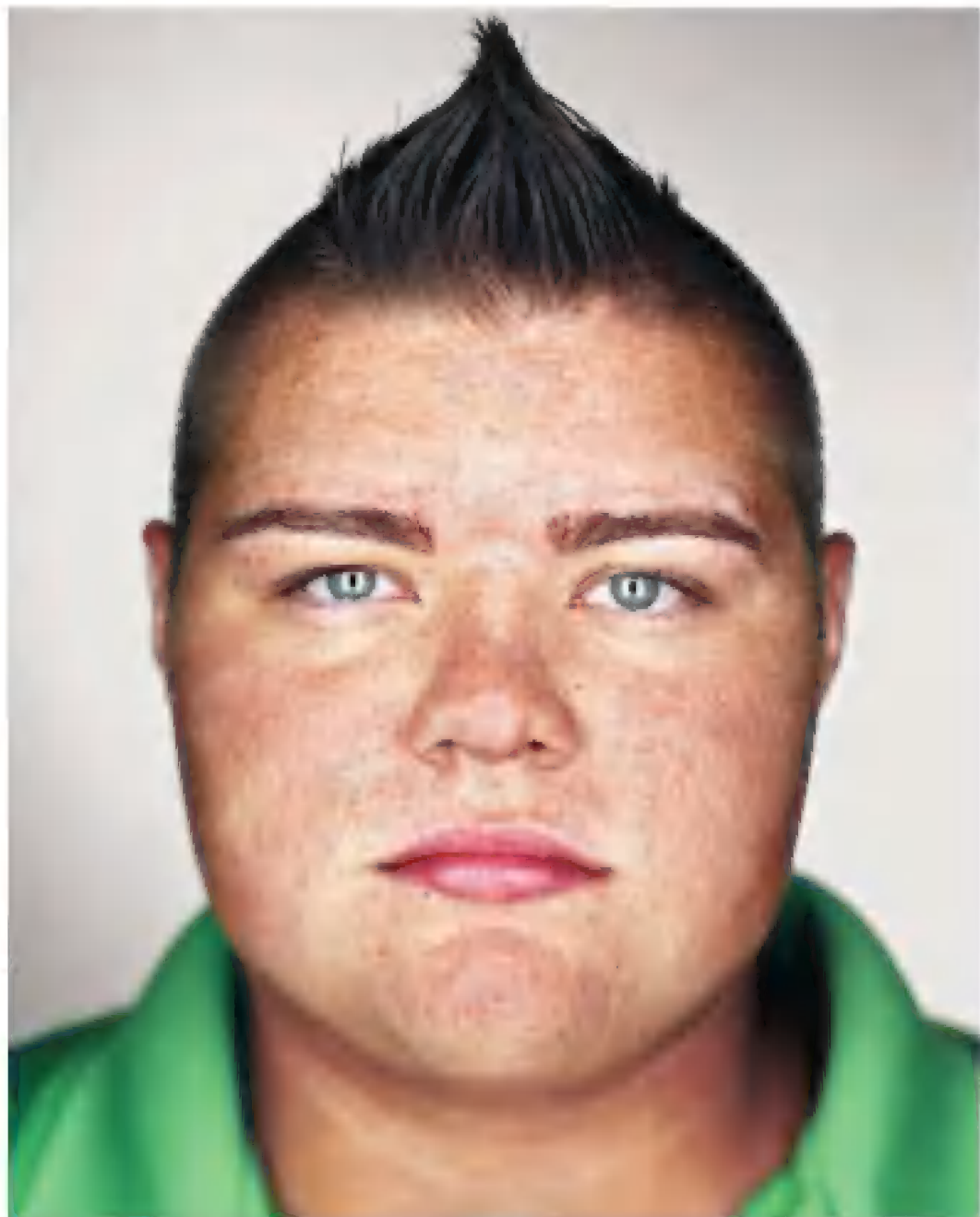


Lorraine

One may be shy, while the other loves meeting new people.



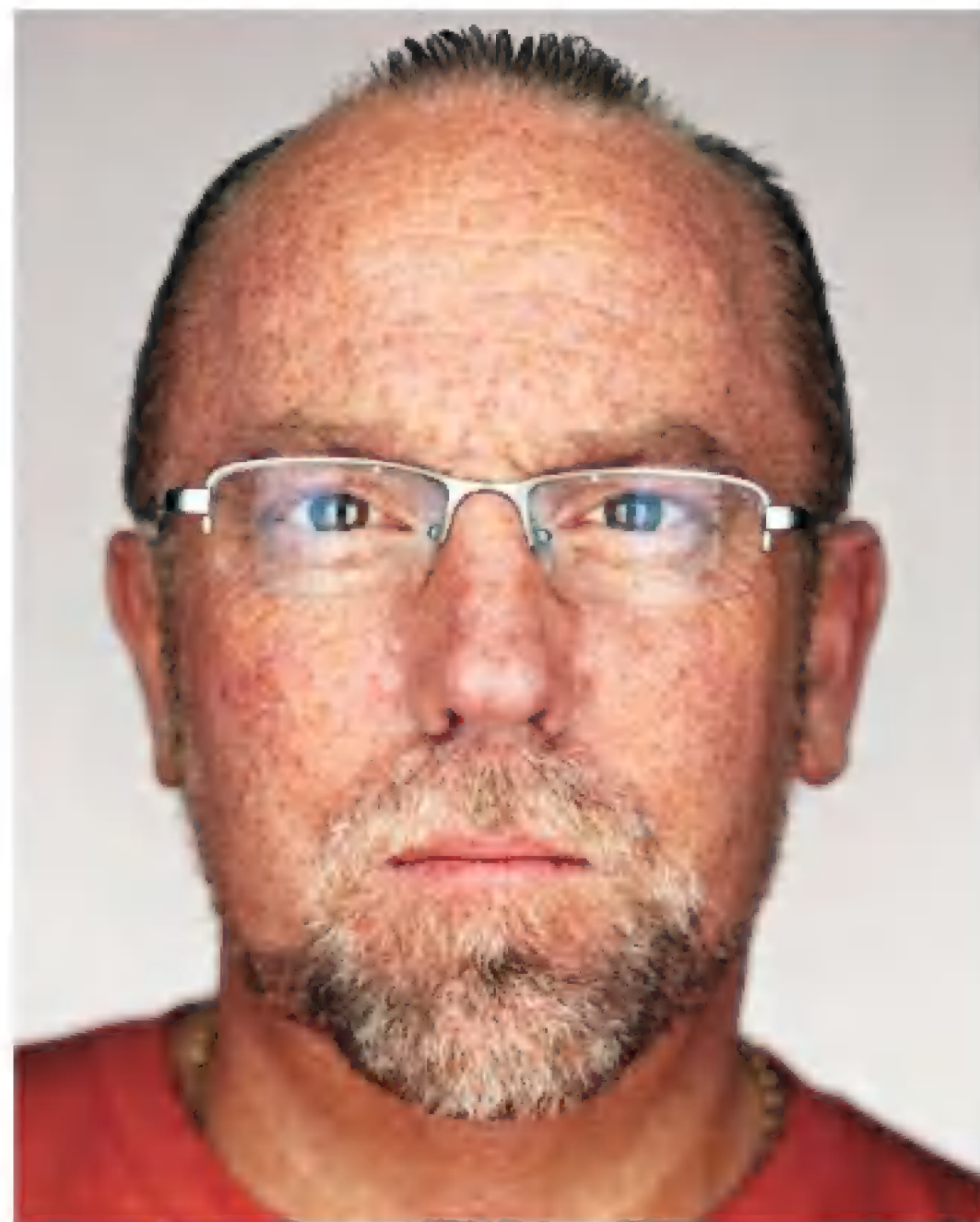
Skyler



Spencer



Jeff



Steve

Discovering why identical twins differ—despite having



Carly



Lily



Jessica



Jackie

the same DNA—could reveal a great deal about all of us.



Cole



Christopher

Every summer, on the first weekend in August, thousands of twins converge on Twinsburg, Ohio, a small town southeast of Cleveland named by identical twin brothers nearly two centuries ago.

Dave and Don Wolf of Fenton, Michigan, have been coming to the festival for years. Like most twins who attend, they enjoy spending time with each other. In fact, during the past 18 years, the 53-year-old truckers, whose identical beards reach down to their chests, have driven more than three million miles together, hauling everything from diapers to canned soup from places like Seattle, Washington, to Camden, New Jersey. While one sits at the wheel of their diesel Freightliner, the other snoozes in the bunk behind him. They listen to the same country gospel stations on satellite radio, share the same Tea Party gripes about big government, and munch on the same road diet of pepperoni, apples, and mild cheddar cheese. On their days off they go hunting or fishing together. It's a way of life that suits them.

"Must be a twins thing," Don says.

This afternoon at the festival the brothers have stopped by a research tent sponsored by the FBI, the University of Notre Dame, and West Virginia University. Inside the big white tent technicians are photographing sets of twins with high-resolution cameras, collecting their fingerprints, and scanning their irises to find out if the latest

face-recognition software can tell them apart.

"Although identical twins may look the same to you and me, a digital imaging system can spot minute differences in freckles, skin pores, or the curve of their eyebrows," says Patrick Flynn, a computer scientist from Notre Dame. But so far, he says, even the most advanced commercial systems can be tripped up by changes in lighting, facial expressions, and other complications, whether imaging twins or others.

Because their beards cover half of their faces, the Wolf brothers pose a particular challenge. This seems to amuse them. "After they took my picture," Dave says, "I asked one guy if I went out and committed a crime and then went home and shaved, would they be able to tell it was me? He kind of looked at me and said, 'Probably not. But don't go out and commit a crime.'"

Nature and Nurture

Flynn and his colleagues aren't the only scientists at work here. With the blessing of the event's organizers, a number of others have set up booths in a small parking lot on the edge of the festival grounds. In the tent next to the FBI project,

They come, two by two, for the Twins Days Festival, a three-day marathon of picnics, talent shows, and look-alike contests that has grown into one of the world's largest gatherings of twins.

researchers from the Monell Chemical Senses Center in Philadelphia are asking twins to sip tiny cups of alcohol to see if they react the same way to the taste. Next to them, doctors from University Hospitals in Cleveland are quizzing twin sisters about women's health issues. Across the courtyard a dermatologist from Procter & Gamble is interviewing twins about skin damage.

To these scientists, and to biomedical researchers all over the world, twins offer a precious opportunity to untangle the influence of genes and the environment—of nature and nurture. Because identical twins come from a single fertilized egg that splits in two, they share virtually the same genetic code. Any differences between them—one twin having younger looking skin, for example—must be due to environmental factors such as less time spent in the sun.

Alternatively, by comparing the experiences of identical twins with those of fraternal twins, who come from separate eggs and share on average half their DNA, researchers can quantify the extent to which our genes affect our lives. If identical twins are more similar to each other with respect to an ailment than fraternal twins

are, then vulnerability to the disease must be rooted at least in part in heredity.

These two lines of research—studying the differences between identical twins to pinpoint the influence of environment, and comparing identical twins with fraternal ones to measure the role of inheritance—have been crucial to understanding the interplay of nature and nurture in determining our personalities, behavior, and vulnerability to disease.

Lately, however, twin studies have helped lead scientists to a radical, almost heretical new conclusion: that nature and nurture are not the only elemental forces at work. According to a recent field called epigenetics, there is a third factor also in play, one that in some cases serves as a bridge between the environment and our genes, and in others operates on its own to shape who we are.

The Jim Twins

The idea of using twins to measure the influence of heredity dates back to 1875, when the English scientist Francis Galton first suggested the approach (and coined the phrase “nature and nurture”). But twin *(Continued on page 54)*



Even when they're not acting in movies like Creeporia, a comedy-horror film, Camille Kitt (at left) and her sister, Kennerly, prefer to dress alike. The twins are also professional harpists and former tae kwon do instructors.





Ranked number one in the world, the doubles team of Mike (at left) and Bob Bryan has won more than 70 championships, including Wimbledon in 2011. The 33-year-olds anticipate each other so well opponents accuse them of being telepathic.





Born in China, Gillian Shaw (at left) and Lily MacLeod were adopted as infants by two Canadian couples—a rare case of twins being knowingly raised apart. The families get together often, allowing the girls to hang out and make up for lost time.



(Continued from page 47) studies took a surprising twist in the 1980s, following the discovery of numerous identical twins who'd been separated at birth.

The story began with the much publicized case of two brothers, both named Jim. Born in Piqua, Ohio, in 1939, Jim Springer and Jim Lewis were put up for adoption as babies and raised by different couples, who happened to give them the same first name. When Jim Springer reconnected with his brother at age 39 in 1979, they uncovered a string of other similarities and coincidences. Both men were six feet tall and weighed 180 pounds. Growing up, they'd both had dogs named Toy and taken family vacations in St. Pete Beach in Florida. As young men, they'd both married women named Linda, and then divorced them. Their second wives were both named Betty. They named their sons James Alan and James Allan. They'd both served as part-time sheriffs, enjoyed home carpentry projects, suffered severe headaches, smoked Salem cigarettes, and drank Miller Lite beer. Although they wore their hair differently—Jim Springer had bangs, while Jim Lewis combed his hair straight back—they had the same crooked smile, their voices were indistinguishable, and they both admitted to leaving love notes around the house for their wives.

As soon as he heard about the two Jims, Thomas Bouchard, Jr., a psychologist at the University of Minnesota, invited them to his lab in Minneapolis. There he and his team gave the brothers a series of tests that confirmed their

similarities. Although each had charted his own course in life, the Jim twins, as they came to be known, seemed to have followed the same paths.

"I remember sitting at a table with them when they first arrived," Bouchard says. "They both had fingernails that were nibbled down to the end. And I thought, No psychologist asks about that, but here it is, staring you in the face."

Skeptics later claimed that such details were exaggerated or that coincidences were just coincidences. But Nancy Segal, a professor of psychology at California State University, Fullerton, attests to the Jim twins' striking similarity. "I met them maybe a year after they were reunited, and they were absolutely on the level," says Segal, who joined Bouchard's team in 1982. "Even though their hair was different, I couldn't remember who was who."

By then, researchers had discovered other twins who'd been separated as infants and reunited as adults. Over two decades 137 sets of twins eventually visited Bouchard's lab in what became known as the Minnesota Study of Twins Reared Apart. The twins were tested for mental skills, such as vocabulary, visual memory, arithmetic, and spatial rotation. They were given lung-function tests and heart exams and had their brain waves measured. They took personality tests and IQ tests and were quizzed about their sexual histories. Altogether, each twin was bombarded with more than 15,000 questions. "We threw the kitchen sink at them," Bouchard says.

Armed with this mountain of data, Bouchard, Segal, and their colleagues set out to unravel some of the knottiest mysteries of human nature: Why are some people happy and others sad? Why are some outgoing and others shy? Where does general intelligence come from? The key to their approach was a statistical concept called heritability. In broad terms, the heritability of a trait measures the extent to which differences among members of a population can be explained by differences in their genetics. By comparing the likelihood that identical twins share a given trait with the likelihood that fraternal twins share the same trait, researchers can

Wherever scientists looked, it seemed, they found the invisible hand of genetic influence helping to shape our lives.



After Doug Malm (at far right) and his twin, Phil, met Jill Lassen (third from right) and her twin, Jena, Doug told Phil to “pick one and don’t be changing.” Today the couples live in the same house in Moscow, Idaho, with Phil and Jena’s son, Tim, and Doug and Jill’s daughter, Rylie.

calculate how much of the difference is due to genetic variation. A person’s height, for example, is often estimated at 0.8, meaning that 80 percent of the differences in height among individuals in a specific population are due to differences in their genetic makeups.

When they looked at the data on twins’ intelligence, Bouchard’s team reached a controversial conclusion: For people raised in the same culture with the same opportunities, differences in IQ reflected largely differences in inheritance rather than in training or education. Using data from four different tests, they came up with a heritability score of 0.75 for intelligence, suggesting the strong influence of heredity. This ran counter to the prevailing belief of behaviorists that our brains were blank slates waiting to be inscribed by experience. More alarming to some, the suggestion that intelligence was linked to

heredity evoked the disgraced theories of the eugenics movements of the early 20th century in England and the United States, which had promoted improvement of the collective gene pool through selective breeding.

“The far-left groups on campus were trying to get me fired,” Bouchard says.

The researchers also questioned how much parenting affects intelligence levels. When they compared identical twins raised in different families, like the Jim twins, with those raised in the same family, they found each pair’s IQ scores to be similar. It was as if it didn’t matter in which family the twins had been raised. That didn’t imply, Bouchard and his colleagues were

Peter Miller is a senior editor. Jodi Cobb is a frequent contributor to the magazine. Martin Schoeller’s portrait of Jane Goodall appeared in October 2010.



"We're wired the same," says Don Wolf (at right) of his twin, Dave, explaining how they've gotten along as truck-driving partners for 18 years. "He's messier than I am," Don says. "But we like the same music and share the same sense of humor."

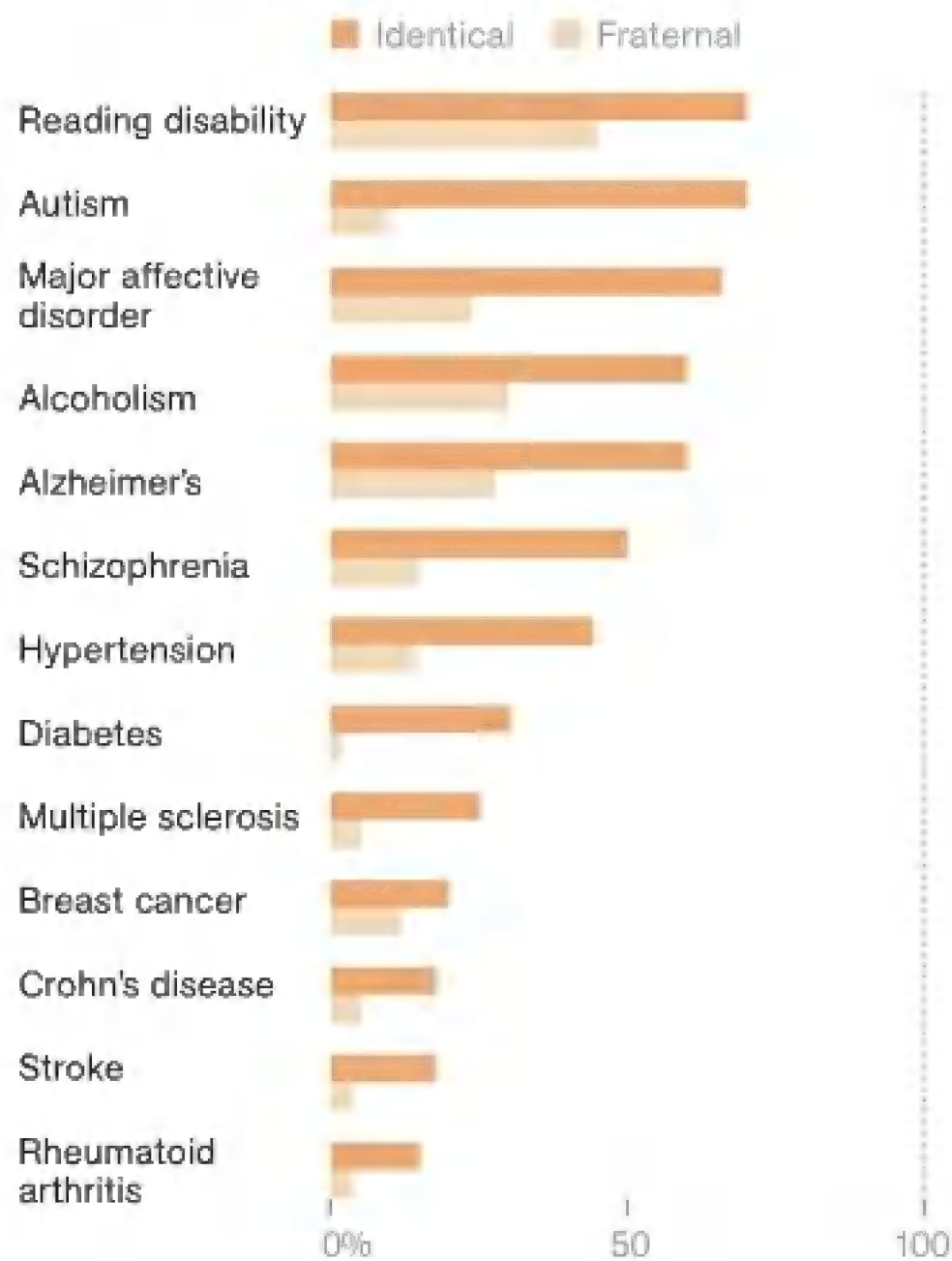
FREIGHTLINER



HATLINER

SHARED TRAITS

Identical twins share certain disorders, such as autism, much more often than fraternal twins do, suggesting the strong influence of heredity.



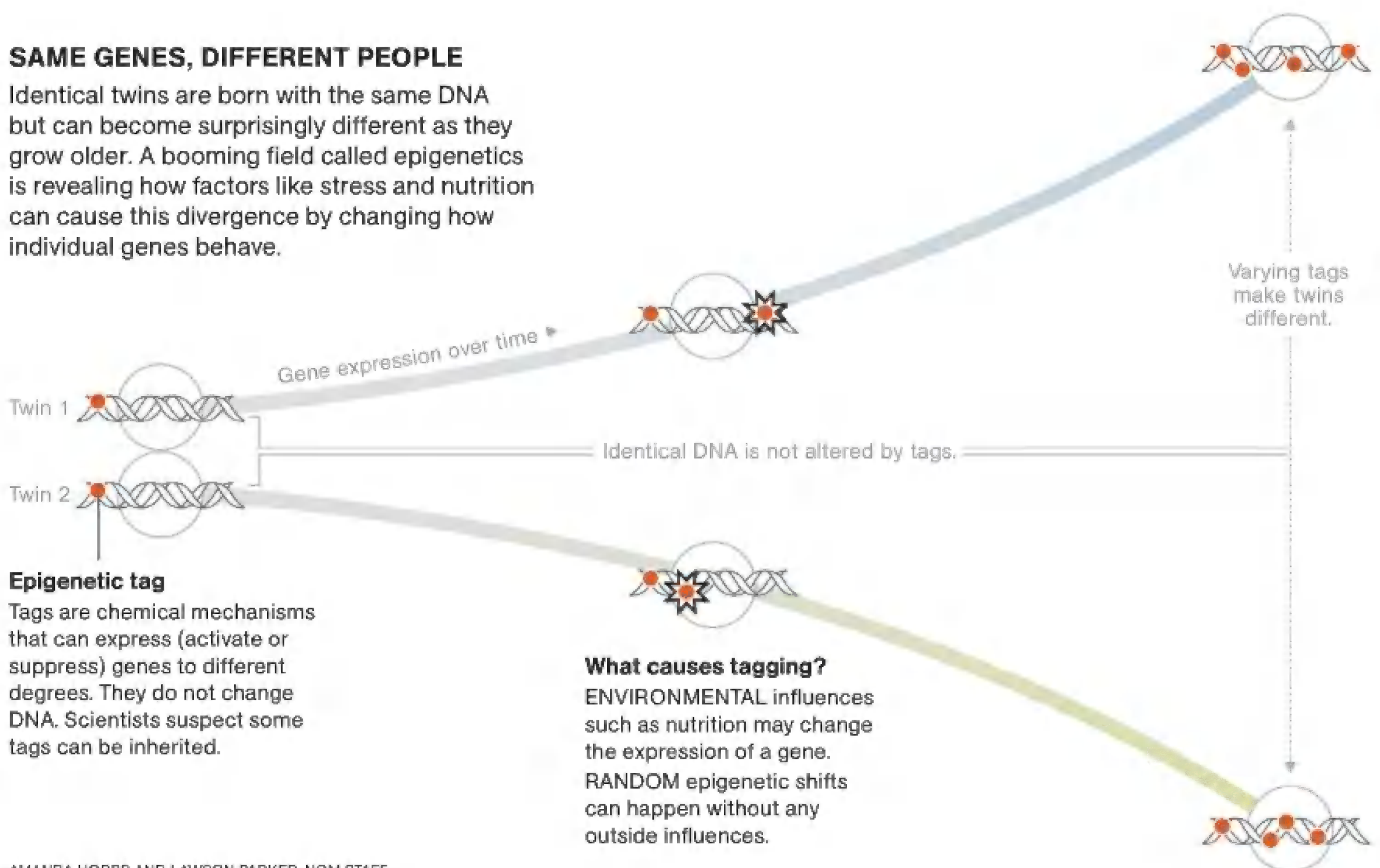
quick to point out, that parents have no impact at all on their children. Without a loving and supportive environment, no child can reach his or her full potential, they said. But when it came to explaining why a particular group of children ended up with different IQ scores, 75 percent of the variation was due to genetics, not parenting.

Besides the Minnesota project, which ended in 2000, other studies have used twins research to examine all kinds of behaviors and attitudes. One investigation, for example, found that an identical twin with a criminal co-twin was more than 1.5 times as likely to break the law as a fraternal twin in the same situation, suggesting that genetic factors somehow set the stage for criminal behavior. Another study found that the strength of an individual's religious fervor was significantly shaped by heredity, though one's choice of affiliation—whether to become, say, a Methodist or a Roman Catholic—was not.

Wherever scientists looked, it seemed, they found the invisible hand of genetic influence helping to shape our lives.

SAME GENES, DIFFERENT PEOPLE

Identical twins are born with the same DNA but can become surprisingly different as they grow older. A booming field called epigenetics is revealing how factors like stress and nutrition can cause this divergence by changing how individual genes behave.



Separated at Birth

For two couples in Canada, the power of DNA to affect behavior is more than an academic question. Since 2000 they've been raising identical twin sisters 275 miles apart in a kind of accidental science experiment.

Lynette and Mike Shaw met Allyson and Kirk MacLeod while using the same adoption agency. The Shaws live in Amherstburg, a rural community near Windsor, Ontario, and the MacLeods live in Sutton, a suburban town near Toronto. In February 2000 they traveled together to Chenzhou, a city in China's Hunan Province, with a small group of prospective parents. When they saw the babies they were adopting, they had the first of many twin moments.

"When the girls came off the elevator, we looked at our daughter and the other child, and I went, 'Wow, she looks just the same,'" Mike says.

"Their cries were the same. Their laughs were the same. You honestly couldn't tell one baby girl from the other," Lynette says.

Before coming to China, the couples had seen photographs of the infants, who were six months old at the time, and they'd wondered if they were sisters. When they asked representatives of the orphanage, they were told the girls weren't related, even though they were listed as having the same birth date. In any event, the couples were told, both children would not be given to a single family for adoption. If the Shaws and MacLeods did not adopt them, the babies would be returned to the orphanage and placed with other families. Under such circumstances, the couples feared, the girls might be separated forever. So they took the babies home to Canada with them, determined to do what was best, even if that meant raising identical twin sisters apart.

So alike yet so different, six-year-old identical twins John and Sam both have autism but function at opposite ends of the disorder's spectrum. While John, who doesn't speak much, flaps his hands in excitement, Sam focuses with laserlike intensity on an iPad.





Diana Bozza comforts her identical twin, Deborah Faraday, at an assisted living facility in Front Royal, Virginia. Diagnosed eight years ago with early onset Alzheimer's disease, Deborah is now completely disabled, while Diana shows no symptoms of the illness.

"The Shaws are part of our extended family now," Kirk says. "We try to get together as much as we can."

The MacLeods make the four-hour drive to Amherstburg—or the Shaws travel to Sutton—every six to eight weeks. As soon as the MacLeods' car stops in the Shaws' driveway, Lily pops out of the backseat and rushes into the waiting arms of her sister, Gillian. Now 12, they both have open faces and shoulder-length black hair, though Gillian recently got pink braces. "They're sisters through and through," Lynette says, looking on. "Like peas in a pod."

The Shaws and MacLeods know how rare their situation is. There are only a handful of other cases, also involving adoptions from Asia, where separated twins are being knowingly raised apart. Their daughters seem to be taking it all in stride.

"I don't hate it. I don't love it," Lily says of being a twin. "But if we lived closer, we could invite each other over for sleepovers."

"Yeah, that would be fun," Gillian agrees.

Because they've kept in close touch, the parents have shared every milestone they've tracked in the twins' development. At 14 months old, for example, both girls took their first steps on the same day—one in Amherstburg, the other in Sutton. They both had small holes in their teeth and amblyopia, or lazy eye, in one eye. Even as toddlers, they both showed the same aggressive streak.

"When she was only two, Gillian would go after older kids on the hockey rink," Mike says. "Sometimes she'd make them cry."

As they grew older, Lily seemed to be the artistic one, Gillian the athlete, spurred on perhaps by the Shaw's other children, Heather and Eric,



At one and a half years old, Declan Conrad (at right) weighs ten pounds more than his identical twin, Finian. The boys began growing at different rates inside the womb, where they had unequal access to blood flow and nutrients from a shared placenta.

who were both into sports. “But then Lily went out for track and won her hundred meter,” Kirk says. “And I came back to that nature versus nurture thing.”

The push and pull between genetics and family life is never far from their minds, the couples say. “We like to think we’re making an impact as parents,” Allyson offers. But then in the middle of a conversation Lily will roll her eyes exactly the way Gillian does, and Allyson is suddenly reminded of her daughter’s twin. “It’s like, whoo!” she says. “Sometimes it will stand the hairs up on the back of my neck.”

The Third Component

That Lily and Gillian seem so similar, despite being raised in different families, underscores the genetic heritage that identical twins share. But for two brothers in Maryland, the

situation is just the reverse. Despite being raised in the same family, these identical twins couldn’t seem more different. What could be so powerful that it trumps the combined effects of nature *and* nurture?

“I saw a cumulus congestus cloud at recess today,” Sam says, making conversation as he waits for his brother, John, to get home from school. “It was very big. Then it broke up into a nimbostratus.”

A bright-eyed six-year-old with glasses, Sam sounds like a professor in a meteorology class. Clouds are his latest passion, his mother says. Before that it was trains, space, and maps. Lately, he’s been working his way through a child’s encyclopedia, gathering facts like a squirrel hoarding nuts, as she puts it.

The twins are both in first grade, but they attend different elementary schools, so that John



With the same casual gait, Ned and Fred Mitchell stroll along the waterfront in Charleston, South Carolina, where they repaired nuclear submarines before retiring in 1996. For twins as close as the Mitchells, living in sync seems to come naturally.





The twins in the photo gallery at the opening of this story look alike—but how alike are they really? To learn more about their similarities and differences, see our iPad issue, available at itunes.com, or visit ngm.com/twins.

can get the attention he needs. (The boys' parents requested that we not publish their last name.) When John's bus drops him off at home, he races inside, and Sam ambushes him with an affectionate hug. John laughs but doesn't speak. When Sam releases him, John walks to a box with stuffed animals and starts flapping his hands in excitement. He's back in his own world.

Both boys were diagnosed with autism spectrum disorder shortly before their second birthday, though John's symptoms are far more severe, including constant movement, trouble speaking, and difficulty making eye contact. Sam has challenges too, mainly with social skills. The fact that they share a developmental disorder is not unusual. When one identical twin is diagnosed with autism, studies have shown, there's about a 70 percent chance the other will be too.

No one knows what causes the disorder, which is diagnosed in about one of every hundred children. Inheritance is thought to play a significant role, though experts believe autism may be triggered by as yet unidentified environmental factors. A study of twins in California last year suggested that experiences in the womb and first year of life can have a major impact.

John's parents wonder if that was the case with him. Born with a congenital heart defect, he underwent surgery at three and a half months, then was given powerful drugs to battle an infection. "For the first six months, John's environment was radically different than Sam's," his father says.

"Things written in pen you can't change. That's DNA," says geneticist Danielle Reed. "Things written in pencil you can. That's epigenetics."

Shortly after Sam and John were diagnosed, their parents enrolled them in a study at the Kennedy Krieger Institute in Baltimore. Blood samples from the boys were shared with a team at nearby Johns Hopkins University looking into the connection between autism and epigenetic processes—chemical reactions tied to neither nature nor nurture but representing what researchers have called a "third component." These reactions influence how our genetic code is expressed: how each gene is strengthened or weakened, even turned on or off, to build our bones, brains, and all the other parts of our bodies.

If you think of our DNA as an immense piano keyboard and our genes as keys—each key symbolizing a segment of DNA responsible for a particular note, or trait, and all the keys combining to make us who we are—then epigenetic processes determine when and how each key can be struck, changing the tune being played.

One way the study of epigenetics is revolutionizing our understanding of biology is by revealing a mechanism by which the environment directly impacts genes. Studies of animals, for example, have shown that when a rat experiences stress during pregnancy, it can cause epigenetic changes in a fetus that lead to behavioral problems as the rodent grows up. Other epigenetic changes appear to occur randomly—throwing a monkey wrench into the engine of nature versus nurture. Still other epigenetic processes are normal, such as those that guide embryonic cells as they become heart, brain, or liver cells, for example.

"During pregnancy, many changes must occur as cells commit to and become progressively specialized tissues, and we know that process involves a cascade of epigenetic programs," says Andrew Feinberg, director of the Center for Epigenetics at Johns Hopkins School of Medicine.

Feinberg's study focuses on a particular epigenetic process called DNA methylation, which is known to make the expression of genes weaker or stronger. To better understand how it relates to autism, Feinberg and his team are using scanners and computers to search samples of DNA from autistic twins for epigenetic "tags," places

along the genome where methylation changes the pattern of gene expression.

The goal of the study, still in progress, is to determine whether individuals with severe autism like John have different methylation profiles than other people. If they do, that might explain how he could turn out so different from Sam. Despite sharing the same keyboard, their bodies are playing different tunes.

It's a promising new approach, says Arturas Petronis, who heads the epigenetics lab at Toronto's Centre for Addiction and Mental Health. Researchers have known for some time that complex disorders such as autism are highly heritable. But intensive scrutiny of DNA sequences themselves hasn't revealed why twins like Sam and John diverge so much in their behavior. "After 30 years of molecular genetic studies we can explain only about 2 or 3 percent of inherited predisposition to psychiatric disease," he says. The rest is still a mystery. That's one reason the National Institutes of Health created the Roadmap Epigenomics Program in 2008, providing \$185 million for research into epigenetics at more than 40 labs.

As Feinberg and Petronis readily admit, such research is still at an early stage. Scientists are only beginning to understand how epigenetic processes relate to complex disorders like autism. The good news is that some of these processes, unlike our DNA sequences, can be altered. Genes muted by methylation, for example, sometimes can be switched back on again relatively easily. And though it may not happen soon, the hope is that someday epigenetic mistakes will be as simple to repair as a piano that's out of tune.

Writing in Pen and Pencil

Back at the Twins Days Festival, Danielle Reed is standing in front of the Monell Center's research booth with a clipboard, asking twins to participate in her alcohol study. She's doing a brisk business, signing up one pair after another. A geneticist by training, Reed has worked with many twins over the years and thought deeply about what twin studies have taught us.

"It's very clear when you look at twins that much of what they share is hardwired," she says. "Many things about them are absolutely the same and unalterable. But it's also clear, when you get to know them, that other things about them are different. Epigenetics is the origin of a lot of those differences, in my view."

Reed credits Thomas Bouchard's work for today's surge in twin studies. "He was the trailblazer," she says. "We forget that 50 years ago things like alcoholism and heart disease were thought to be caused entirely by lifestyle. Schizophrenia was thought to be due to poor mothering. Twin studies have allowed us to be more reflective about what people are actually born with and what's caused by experience."

Having said that, Reed adds, the latest work in epigenetics promises to take our understanding even further. "What I like to say is that Mother Nature writes some things in pencil and some things in pen," she says. "Things written in pen you can't change. That's DNA. But things written in pencil you can. That's epigenetics. Now that we're actually able to look at the DNA and see where the pencil writings are, it's sort of a whole new world."

For six-year-old twins Sam and John, that world seems filled with new promise. John has found his voice lately, expanding his vocabulary beyond one-word commands. "I want to go swim big pool with Mommy Daddy Sam John," he blurted out one evening at the neighborhood pool. "Holy macaroni, a 12-word sentence uttered by a most quiet boy," his mother celebrated in her blog. "A most quiet boy who this summer is something else: a boy who wields his words instead of pulling me places."

Sam, for his part, has been devouring books on Greek mythology and orthopedics, a pairing of subjects prompted by a broken elbow. After reading the tale of Icarus, who flew over Crete on wings of feathers and wax, he decided to give it a try from the top of the living room couch, ending up in the emergency room. That gave him time, while convalescing at home, to dig into the medical textbook.

Each boy in his own way is trying to fly. □

THE GOLDEN CHIEFS OF PANAMA



The excavation of a cemetery more than a thousand years old has uncovered tombs of powerful warriors adorned in gold. One of the richest discoveries in the Americas in decades, the site is shining new light on a little-known culture.

BREASTPLATE WITH SQUID DESIGN 7.8 INCHES WIDE; ARM CUFFS 2.4 INCHES WIDE; HUMAN-HEADED PENDANT 4.7 INCHES TALL







Near the cemetery at El Caño, stone monoliths rise to more than six feet. War captives may have been lashed to them before being sacrificed and buried with chiefs during funerals that involved days of feasting and dancing.



FOR SCALE, SEAHORSE PENDANT IS 3.1 INCHES TALL. UNLESS OTHERWISE SPECIFIED, ARTIFACTS COURTESY NATIONAL HERITAGE OFFICE (DNPH), NATIONAL INSTITUTE OF CULTURE (INAC), PANAMA; PHOTOGRAPHED AT SMITHSONIAN TROPICAL RESEARCH INSTITUTE



The personal treasures of a chief include a seahorse pendant, ear ornaments, part of a breastplate, a necklace, and plaques. All were buried in a bag studded with the surrounding stone beads, which scattered as the fibers decayed.



J.P.

BY A. R. WILLIAMS

PHOTOGRAPHS BY DAVID COVENTRY



IN A GRASSY, SUN-PARCHED FIELD IN CENTRAL PANAMA, gold was coming out of the ground so fast that archaeologist Julia Mayo was tempted to yell, Stop, stop! For years she had been working for this moment, waiting for it, but now she was overwhelmed.

Determined to uncover new evidence of the ancient society she had been studying since graduate school, Mayo and her team began geophysical surveys in 2005 at a site known as El Caño, named for a waterfall on one of the area's many rivers. The results identified a circle of long-forgotten graves. By 2010 she and her team had dug a pit 16 feet deep and discovered the remains of a warrior chieftain bedecked in gold—two embossed breastplates, four arm cuffs, a bracelet of bells, a belt of hollow gold beads as plump as olives, more than 2,000 tiny spheres arranged as if once sewn to a sash, and hundreds of tubular beads tracing a zigzag pattern on a lower leg. That alone would be the find of a lifetime, but it was just the beginning. Mayo had struck a lode of treasure.

The team returned last year during the January-to-April dry season and unearthed a second burial every bit as rich as the first. Bearing two gold breastplates in front, two in back, four arm cuffs, and a luminous emerald, the deceased was surely another supreme chief. Near him lay a baby similarly adorned in gold, most likely his son. Beneath both of them stretched a layer of tangled human skeletons, possibly sacrificed war captives. Radiocarbon tests would date the burials to about A.D. 900—the era when the Maya civilization, some 800 miles to the northwest, was beginning to unravel.

Mayo barely had time to catalog the new finds before her team uncovered more gold. Glinting from the walls of the pit, the artifacts marked the edges of four more tombs. As she surveyed the scene, she couldn't help but feel stunned. "I was just speechless—fascinated, but also worried," she remembers. The rains had already begun, and she was now in a race to retrieve all the treasure before the neighboring river flooded the site. Also, she knew looters were sure to come if news of the discoveries got out. She swore her team to silence and prayed for clear skies.

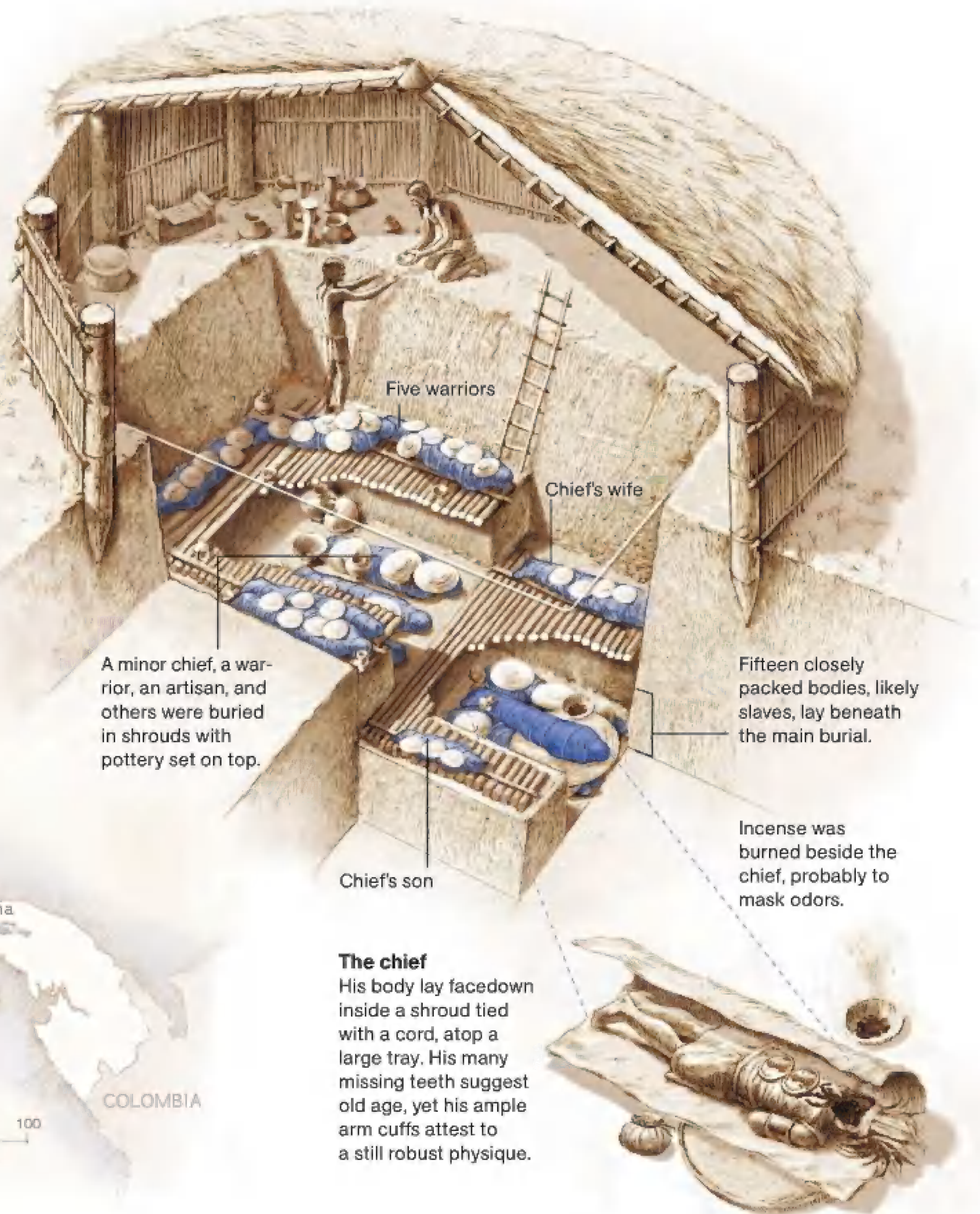
This wasn't the first time that an archaeological gold mine had been found in Panama. Less than two miles from where Mayo is working, excavations at Sitio Conte—named for the owners of the land—had unearthed one of the Western Hemisphere's most spectacular collections of artifacts. That trove first came to light in the early 1900s, when a rain-swollen river sliced into a cattle pasture. Golden breastplates, pendants, and other finery began tumbling out of tombs and cascading down the riverbank.

Lured by news of the ancient cemetery, teams from Harvard and later the University of Pennsylvania set off on the six-day voyage by steamer from New York to Panama City, then made their way to Sitio Conte by horse, oxcart, and dugout canoes. During four field seasons, digging in temperatures that often topped a hundred degrees,

This illustration of what a chief might have looked like was inspired by regalia recovered from a grave and written descriptions left by Spanish explorers.

BURIAL PIT

Located near Panama's Pacific coast, this tiered tomb held a supreme chief, people sacrificed to serve him for eternity, and containers of food. The pit was open and roofed, perhaps for visits by survivors.



Five warriors

Chief's wife

A minor chief, a warrior, an artisan, and others were buried in shrouds with pottery set on top.

Fifteen closely packed bodies, likely slaves, lay beneath the main burial.

Chief's son

Incense was burned beside the chief, probably to mask odors.

The chief

His body lay facedown inside a shroud tied with a cord, atop a large tray. His many missing teeth suggest old age, yet his ample arm cuffs attest to a still robust physique.

the teams opened more than 90 tombs, many holding multiple bodies adorned in gold as well as works by highly skilled artisans: intricately painted ceramics, carved whale bones accented with gold, necklaces of sharks' teeth, ornaments of polished serpentine and agate.

In his 1937 report Harvard archaeologist Samuel Lothrop identified the Sitio Conte people as one of the native groups the Spanish had encountered when they invaded Panama in the early 1500s. As the conquistadores marched across the isthmus, they wrote detailed chronicles of their progress. In the Sitio Conte region

they found small, belligerent communities vying for control of the savannas, forests, rivers, and coastal waters. Their warrior chiefs covered themselves in gold to proclaim their rank as they fought each other and the Spanish. The conquistadores accumulated a fortune in gold for the royal coffers back in Seville as they defeated chief after chief. From one funeral alone they plundered 355 pounds of gold, including jewelry that they tore from the bodies of three chiefs who had been mummified over a smoking fire after falling in battle.

The Sitio Conte culture is much older than it first appeared to Lothrop. Experts now believe the graves of the warrior chiefs date from about the eighth to the tenth centuries. The artifacts appeared to match the descriptions left by the

A. R. Williams is a senior writer for National Geographic. Photographer David Coventry is based in Brooklyn, New York.



Under the direction of archaeologist Julia Mayo, standing at far left, the team at El Caño uncover gold ornaments in a chief's burial some 16 feet below ground level. In the background, the middle tier of a second tomb is being excavated.

conquistadores because some aspects of the culture had continued unchanged until the 1500s.

By April 1940 the archaeologists working at Sitio Conte had found a wealth of dazzling artifacts for their museums, and so they departed. A few others continued to probe beneath Panama's green pastures, but they failed to make remarkable discoveries. This stretch of Central America has none of the attractions that have drawn generations of scientists to the Maya territory to the north—no enduring architecture, dynastic histories, or evidence of intellectual accomplishments such as a calendar. The heat and humidity have rotted away ancient shelters of bamboo and thatch along with most personal possessions, leaving mainly broken pottery and stone tools.

A SHORT WALK from the same river that flows by the Sitio Conte cemetery, there is a line of tall monoliths that crosses the field at El Caño. In 1925 the stones attracted an American adventurer named Hyatt Verrill. He dug several rough holes nearby, uncovering three skeletons of commoners. Additional excavations in the 1970s and 1980s found several more modest graves but no treasure.

Despite those unpromising results, Julia Mayo had a good feeling about this site. As a research associate at the Smithsonian Tropical Research Institute in Panama City, she had studied Lothrop's report on Sitio Conte. She knew he

■ **Society Grant** Julia Mayo's work at El Caño was funded in part by your Society membership.





El Caño's only intact skull, above, wrapped in fabric for transport to the lab, belonged to someone sacrificed to accompany a chief to the next world. The head lay at an unnatural angle to the body, perhaps indicating a broken neck. Two tiny figures of gold and resin were found atop the lower jaw. A similar figurine with gold hands, left, was buried with the chief, whose bones, like most at this site, decomposed long ago as a result of seasonal floods.

FIGURINE HANDS 0.8 INCHES LONG



PENDANTS (TOP TO BOTTOM): 1.2 INCHES TALL; 2 INCHES TALL; 4.9 INCHES LONG. PENDANT WITH EMERALD (NO. 40-13-27)
COURTESY UNIVERSITY OF PENNSYLVANIA MUSEUM; PHOTOGRAPHED AT DENNOS MUSEUM CENTER, TRAVERSE CITY, MICHIGAN
STATUES (FACING PAGE): 3.9 TO 4.6 FEET TALL. COURTESY REINA TORRES DE ARAÚZ ANTHROPOLOGICAL MUSEUM/DNPH, INAC



Above: These statues once stood on the plaza at El Caño. The fragment at left may show a war captive awaiting his fate—his hands are tied behind his seated body, now headless. Opposite: Animal-shaped pendants, like this two-headed gold bat and a stone falcon, adorned the dead. The gold pendant of a chief from nearby Sitio Conte, set with an emerald, represents an imaginary creature.

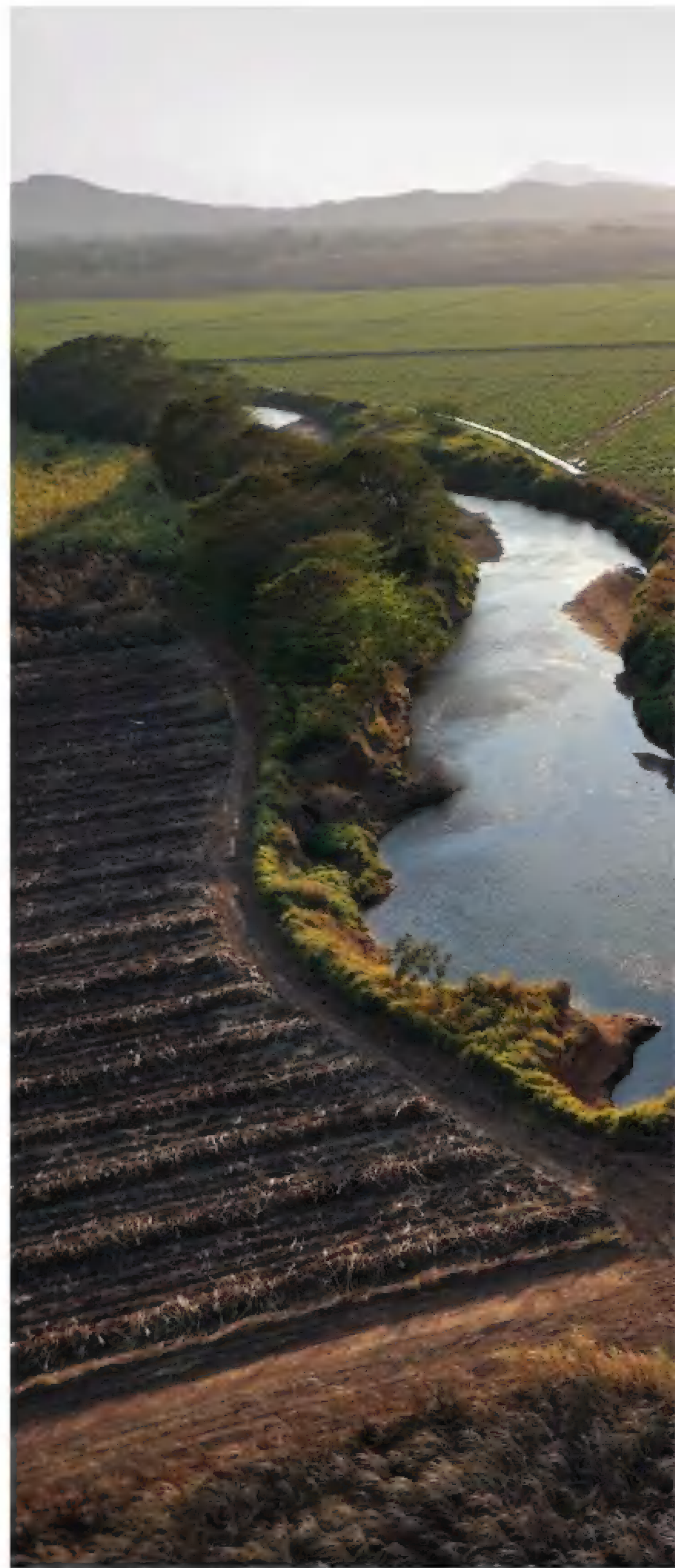
had found monoliths as well as graves, and she thought there might be a connection. If she was right, more burials of warrior chiefs from that same culture would be waiting underground at El Caño. It was just a question of figuring out where.

Her initial survey picked up traces of a slightly raised circle about 260 feet in diameter. Hoping it was the border of a cemetery, she started digging at dead center—and hit pay dirt. The artifacts now coming to light confirm that the Spanish descriptions of this region are generally reliable and that Sitio Conte was not a fabulous exception in an archaeological backwater.

Specialists at the Smithsonian Institution are analyzing the array of materials Mayo's team has unearthed and have already made a major discovery. Natural impurities in the gold indicate that the metal was mined and worked in the region. This firmly puts to rest any debate about whether Panama's treasures were imported from farther south, where cultures were supposedly older and more advanced. The native people in this area may have lived in simple huts, but they were rich enough to support master craftsmen and sophisticated enough to appreciate fine art.

Mayo believes her cemetery holds about 20 more tombs of chiefs like the two she has excavated. When she estimates how long it would take to uncover them all, the number is so extreme it sounds like a joke—until you do the arithmetic. Her team of ten works slowly, scraping back the hard alluvial soil with care to gather the smallest pieces of evidence. In four years they have exposed 2 percent of the cemetery. If work were to continue every year at that pace, the last artifact would be plucked from the ground 196 years from now.

During the digging season, as Mayo and her team eat lunch on the shady porch of El Caño's small museum, they look out across hundreds of acres of sugarcane. Mayo believes it's all fertile ground for archaeology. Just a few miles upriver, in fact, she has found signs of another cemetery. If it's as rich as El Caño and Sitio Conte, this area could be Panama's Valley of the Kings. In Egypt, though, most of the tombs have been looted. Here they should still be full of surprises. □





A winding river cuts through fields of sugarcane around El Caño, located in the grove of trees beneath the central mountain. The waterway's shores, perhaps considered sacred long ago, may hold many more graves yet to be discovered.



TWO YOUNG DANES FIND OUT IF THEY'RE TOUGH ENOUGH

Setting out in the middle of winter, a dogsled team patrols northeastern Greenland.



THE COLD

FOR THE WORLD'S ONLY MILITARY DOGSLED TEAM.

PATROL



In terrain where six miles an hour is fast, a sled team makes quick time over Shannon Sound. When the elements conspire, covering a mile a day is a feat—with occasional stops to dig out the sled.



BY MICHAEL FINKEL

PHOTOGRAPHS BY FRITZ HOFFMANN

It was dark when Jesper Olsen fell.

Dark and cold. In wintertime in northern Greenland there's not so much as a single ray of sunlight for more than three months. The average temperature is 25° below zero F. The wind is brutal.

Jesper was equipped for the climate, just as he was prepared for the unruly dogs and the overloaded sled and the rugged terrain and the

thin cross-country skis. He was even ready to fall. What Jesper hadn't anticipated was that as he tumbled down the sheer, rock-strewn slope, his knife would dislodge from the leather sheath on his waist and rotate in a perfectly unlucky way. Jesper landed on it. The blade pierced his right thigh.

His partner, Rasmus Jørgensen, did not see the accident. Rasmus had traveled a little ahead, his headlamp cutting a wedge in the darkness amid the black monolithic peaks and pale shoreline. Before losing his balance, Jesper had been positioned behind the heavy sled and 13 dogs, grasping onto the guide ropes, trying to control the team's descent. Now he lay sprawled on the



Rotating their arms to stay warm, Jesper Olsen (at right) and Rasmus Jørgensen ski beside a sled full of supplies: rifles, a radio, first aid, a tent, sleeping bags, a big map, and plenty of dog food.

ice-encased tundra, a gash in his ski pants and blood seeping down his leg.

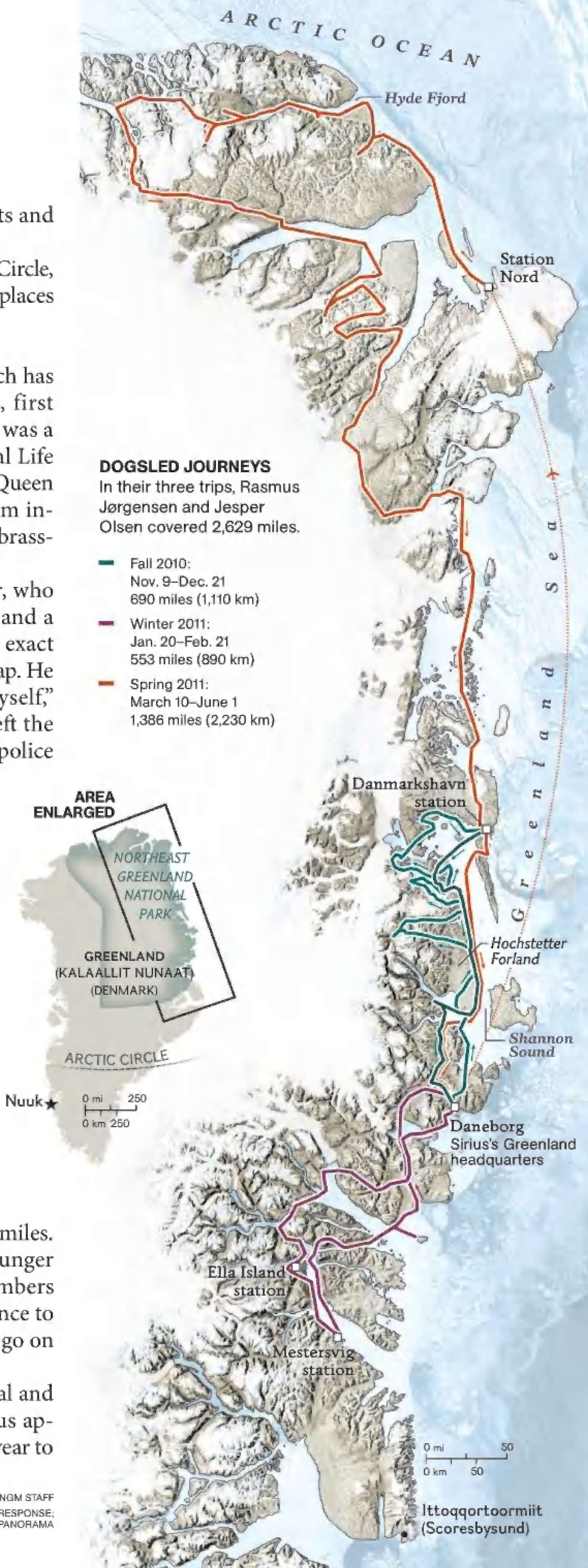
They were 500 miles north of the Arctic Circle, in one of the loneliest and least hospitable places on Earth.

THE DESIRE TO EXPLORE Greenland, which has been a Danish protectorate since 1721, first came to Jesper six years earlier, when he was a 23-year-old sergeant in the Danish Royal Life Guards, supervising troops at three of the Queen of Denmark's palaces. His official uniform included an enormous bearskin hat and a brass-buttoned jacket.

This was not his life's ambition. Jesper, who has pale blue eyes and dirty blond hair and a powerful, natural athleticism, craved the exact opposite of marching around in a fancy cap. He wanted an adventure. "I like to push myself," he says. It wasn't until 2008, after he'd left the Royal Guards to become a Copenhagen police officer, that Jesper got up the nerve to apply for an elite special forces unit that is legendary in Denmark for driving soldiers to the limits of self-deprivation and mental fortitude. He decided to try out for Sirius.

For more than 60 years, Sirius has been entrusted with patrolling northeast Greenland's 8,699-mile coast. The 12-man team visits each inch of the cracked and ragged coastline at least once every five years, formally supporting Danish sovereignty under international conventions. Sirius is the world's only military dogsled patrol. The job—low pay, no holidays—entails journeying with a partner and a dog team for 26 months and more than 5,000 miles. Injuries are virtually inevitable, as are hunger and exhaustion and frostbite. Team members are stalked by polar bears. There's no chance to visit family or friends, no opportunity to go on a date. They never even get to see a tree.

Jesper passed a battery of psychological and physical tests that winnowed down Sirius applicants. Only six people are chosen each year to



MARTIN GAMACHE, NGM STAFF

SOURCES: DANISH NATIONAL SURVEY AND CADASTRE; MODIS RAPID RESPONSE; NG BOOKS; SIRIUS; VIEWFINDER PANORAMA



BATMAN



INDY



ARMSTRONG



SALLY



JOHAN



HANSEN



SINGERNEQ



SIGURD



HJØRDIS

Each dog's role fits his or her personality. Intelligent and confident, Johan is the alpha dog. Hjørdis was best at alerting the patrollers about polar bears during the 2010-11 trips.

replace outgoing patrollers. Women are eligible, though none have yet applied. Everyone must be under 30 to try out.

Just weeks before the Sirius trainees were to leave for an outdoor-survival program in Greenland, Jesper heard the news: He was the final man cut. He was devastated. "I was never going to apply again," he says.

He returned to the police force but could not stop thinking about the stark beauty and consummate challenge of the far northern wilds. His parents had supported his ambition; he did not have a girlfriend. So he changed his mind and tried once more. He subjected himself to the eight-month training regimen. He learned

DOGSLEDDING EXISTS AT THE INTERSECTION OF CHAOS AND SKILL.

everything from meteorology to hunting skills to veterinary medicine; he memorized the shape of more than 600 fjords and points along the Greenland coast in case he lost his map.

This time, Jesper made the cut. As part of his final training, he leaped into icy water to simulate a sledding disaster, then lived for five days with only a small bag of emergency supplies, sleeping in a snow cave he dug with a tin cup and hunting arctic hare or musk ox to eat. At last, in July of 2010, he reported for duty at the Sirius base in northeastern Greenland, a collection of blocky buildings, connected with ropes so one can navigate in whiteouts, perched on a lonely spit of land. He was officially a Sirius patroller.

HE FOUND AN IDEAL PARTNER in Rasmus, a 28-year-old second-year patroller and former Air Force sergeant with a scruffy red beard, a weight lifter's might, and a Buddha-like unflappability. Together, in the Sirius wood shop, they built a 14-foot sled, the runners made of nylon and the boards joined with twine rather than nails for maximum flexibility. They named it Black Sun. They worked with their dogs until they felt like a cohesive unit.

In mid-October, when the seas froze—sledding just offshore is often the most efficient way to travel—they loaded Black Sun with 815 pounds of supplies and left base, following a route set by Danish military officers. With the other five teams, Rasmus and Jesper act as the only rangers in Northeast Greenland National Park, supporting scientific and sporting expeditions in the world's largest park, home to vast herds of musk oxen and hundreds of polar bears.

But four days into his first ever trip, Jesper stabbed himself in the leg. He lay on the snow, pain washing over him, fervently hoping that his dream of serving as a Sirius patroller had not slipped away just as it was beginning.

He convinced himself, within a few moments, that the injury was manageable. Probably, he thought, he'd landed on a rock. During his intense Sirius training, he'd learned to remain composed no matter how dire the situation, and he'd been indoctrinated in the Sirius ethos: Whenever possible, out on the ice, it's best to continue moving.

So without even peeking at the wound, without yet noticing the slice in his pants or the blood trickling down, Jesper rose to his feet. He retrieved his knife. Rasmus and he exchanged no more than a few words.

"You OK?"

"Yeah."

Then each man grabbed a rope tied to the sled and stood solidly on his skis. "Ya!" Rasmus shouted. The dogs snapped their lines taut, and the sled, and the men, lurched violently forward.

DOGSLEDDING EXISTS at the intersection of chaos and skill. To keep the team moving, Jesper and Rasmus continually interacted with their dogs—whistling, scolding, cajoling, praising. They were crossing a peninsula called the Hochstetter Forland, bouncing over rocks, chugging up hills and sliding down, a fog of frozen breath, from both dogs and humans, forming a vapor trail hanging

Fritz Hoffmann covered the Shaolin tradition of kung fu in March 2011. In April, Michael Finkel described dropping into Congo's Nyiragongo volcano.



Their lives spent outdoors, reserve dogs at Station Nord are chained far enough apart to avoid fights. Sanne, perched atop a doghouse, gets a hug from base leader Søren Engkjær Hansen.





Sled dogs become passengers on a flight to Greenland's remote northern coast. Station Nord crew member Troels Guld positions himself in the middle of the pack—as alpha dog—to maintain order.



silently behind them. Shark-fin mountains rose out of frozen seas. Icebergs parked offshore looked like bleached battleships.

Normal sledding pace is less than five miles an hour. When Jesper crashed, they were a little more than halfway through the day's goal of 21 miles, part of a looping, month-and-a-half-long, 690-mile expedition north of the Sirius base, the shortest of three trips they'd planned for the year.

A day of dogsledding is constant and all-consuming work; Jesper hardly had time to give his throbbing leg much thought. A lunch break was not an option. The men grabbed sips of water, the dogs lapped snow. If the team is not in sync, a Sirius sled can feel like a body with 13

minds. The dogs, tethered in pairs on one long line, sometimes grow stubborn and lie down. There are fights, jealousies, love interests—Jesper and Rasmus's team had two females. The dogs can work together beautifully one minute, and the next become a snarling ball of flying fur, the snow dotted with bright blood.

"It's like being a cop again, when hell suddenly breaks loose," Jesper says. "You have to get in there and tear the dogs apart."

In this modern military age of Humvees and Abrams tanks, there's still no better way than dogsledding to traverse long distances in Greenland, where engine failure can be deadly. Numerous times, dogs have saved patrollers'



As the sun sets, the team drives toward an iceberg in Hyde Fjord near the top of Greenland. After two years with the dogs, "you know them better than high school friends," Rasmus says.

lives. Sledding during the endless night, especially in fog, is often performed half blind. The dogs have stopped short at cliff edges and refused to move even when prodded. They also make a specific polar bear warning sound, a hissing growl, that lets patrollers know when to be alert.

THOUGH JESPER AND RASMUS were in the first week of their inaugural trip, they'd already agreed on a particular style. Some Sirius pairs prefer traveling light and fast; extreme weight-phobes cut tags from T-shirts and handles off toothbrushes and ration the fuel for their camp stoves. Jesper and Rasmus represented the slow and warm approach: They brought all the clothing

IF THE TEAM IS NOT IN SYNC, A SIRIUS SLED CAN FEEL LIKE A BODY WITH 13 MINDS.

they desired, and never worried about sacrificing a warm meal. Their motto, Rasmus says, was "We never run out of fuel."

So there was no hurry as they moved across the Hochstetter Forland. Patience and precision were more important than speed. Any miscalculation in the far north can be dangerous—put your gloves down in the wrong spot for an instant and they'll blow away. "You'll be punished if you're not doing everything right," Rasmus says. The only fatality in Sirius history, in 1968, occurred when a patroller became separated from his partners on a training ride, lost amid swirling snow, and was unable to survive the storm alone.

At the end of the day, Jesper and Rasmus halted the sled and launched into a precisely choreographed routine. While the northern lights blazed overhead in neon pinks and greens, Jesper set up the tent—some nights are spent camping, some in huts scattered along the coast—then unrolled the ultra-insulated sleeping bags and lit the stoves inside the well-ventilated shelter. For extra warmth, Jesper and Rasmus liked to use three stoves at once.

Rasmus carefully staked out the dogs, making

sure they were separated enough to prevent contact. He then spent a little time with each one. "They become your family," Jesper says. Rasmus bear-hugged their proud lead dog, Johan; their cheerful female, Sally; their resident troublemaker, Indy; and their legend, Armstrong, who was in his tenth winter as a sled dog—a Sirius record, twice as long as most dogs serve. Armstrong had hauled a sled at least 25,000 miles, more than a lap around the Equator.

Rasmus knew that Armstrong was nearing the end of his career. There's no room at the Sirius base for retired dogs. And the dogs—as much wolf as pet—cannot be adopted. They must be euthanized, an act the patrollers do themselves with a pistol. Both Rasmus and Jesper say it's the most difficult part of the job.

INSIDE THE TENT, stoves running full throttle, Jesper and Rasmus finally thawed out. At minus 40°F materials like plastic become as brittle as glass. About 60 below, the dogs start to suffer; sores, from the sharp snow, open on their paws. At minus 70 you must stop and camp.

Dinner was a one-pot stew of tomato soup, pasta, cream cheese, and canned mini-sausages: not quite enough to replace the burned calories. Some patrollers lose as much as 30 pounds during a winter. Relationships between patrollers—for the better part of a year, the only humans they'll see—aren't always amicable. But once out on the ice, there is no option of divorce. Jesper and Rasmus were a harmonious match. The closest they came to a disagreement was over pipe smoking. Rasmus, following classic Sirius tradition, enjoyed an evening smoke. Jesper couldn't stand it.

As the stew simmered, Jesper finally had time to examine his wound. He wriggled out of his ski pants, and it was only then he saw the deep gash in his leg and the blood that had spilled—and continued to ooze—and he knew for certain he'd landed on his knife.

Jesper hardly reacted. He was a Sirius patroller, after all. He simply took out the first aid kit. He cleaned up the blood. And he patched himself up. □

“I have a beautiful voice, but my body is not whole,” says singer Sovanreaksmey Kheng, who at age ten lost his right hand and eye in a detonator explosion. He is one of many land mine survivors in a nation on the mend.

THE HEALING FIELDS

**LAND MINES ONCE CRIPPLED
A WAR-RAVAGED CAMBODIA.
TODAY THE NATION IS A MODEL
FOR HOW TO RECOVER FROM
THIS SCOURGE.**



More than 1,600 mines have been removed from this area in Bour, a village in Cambodia's Battambang Province, where Hun Krat scans for buried devices. Villagers come here to cut grasses for roof thatch.





គ្រោះថ្នាក់ខ្ពស់
DANGER, MINERAL

BY MARK JENKINS

PHOTOGRAPHS BY LYNN JOHNSON

DELICATELY BRUSHING AWAY THE SOIL with his fingers, Aki Ra uncovers a dark green land mine buried two inches beneath the overgrown dirt road. The size of a large soup can, the mine was planted by the Khmer Rouge about 15 years ago on this ox track in northwestern Cambodia—the most densely mined region of one of the most heavily mined countries in the world.

“This is the type 69 Bouncing Betty made in China,” says Aki Ra, his breath fogging the blastproof visor of his helmet. Bouncing Betty is the American nickname for a bounding fragmentation land mine. The pressure of a footstep causes it to leap out of the ground and then explode, spraying shrapnel in every direction. It can shred the legs of an entire squad.

Soft-spoken and cherubic, Aki Ra knows the inner workings of the Bouncing Betty and just about every other variety of mine. In the mid-1970s, when he was five, the Khmer Rouge separated him from his parents and took him into the jungle with other orphans. At that time, Pol Pot, commander of the Khmer Rouge, had plunged the country into chaos, closing schools, hospitals, factories, banks, and monasteries; executing teachers and businessmen; and forcing millions of city dwellers into a gulag of labor camps and farms. The small hands of children like Aki Ra were invaluable tools. He was trained to lay land mines, defuse and deconstruct enemy mines, and reuse the TNT for what are now called improvised explosive devices (IEDs).

Some years later, when Vietnamese forces invaded Cambodia, they dragooned Aki Ra into their army, and he was forced to fight against his former captors. When the United Nations' peacekeeping forces finally arrived in 1992, he'd

been living in the jungle for some 15 years. He joined the UN as a deminer. When the peacekeepers left two years later, much of the best agricultural lands—vegetable gardens, pastures, rice fields—were still mined. Farmers trying to reclaim their fields were being blown to pieces. For a decade and a half, using only a knife and a stick, Aki Ra worked as an unpaid sapper, defusing rather than detonating land mines, reclaiming his country one square foot at a time. By his own count, he has defused some 50,000 devices: blast mines, antitank mines, bounding mines, and other explosives.

“I found a lot of mines that I laid,” he says with a conflicted sense of pride and shame.

Now a certified deminer, he has his own squad, the Cambodian Self Help Demining team, partially funded by the U.S. The deminers use special metal detectors to search for explosives; that's how they found the Bouncing Betty.

Sweat is dripping off Aki Ra's face as he carefully places a small charge beside the land mine, attaches wires, and runs a thin cable a hundred yards away. Like all official demining organizations, Aki Ra's team no longer defuses land mines but detonates them in situ instead. Squatting behind a tree, he pushes the red button. The explosion is terrifying. With half a grin, Aki Ra says, “One less land mine, one less child without a leg.”



Aki Ra, founder of the Cambodia Landmine Museum, displays mines he defused. As a child he was forced by the Khmer Rouge to plant some of the same types of mines.

IN THE WARFARE that raged in Cambodia from 1970 until 1998, all sides used land mines. There are more than 30 different types. Villagers have prosaic names for them based on their appearance: the frog, the drum, the betel leaf, the corncob. Most were manufactured in China, Russia, or Vietnam, a few in the United States. Pol Pot, whose regime was responsible for the deaths of some 1.7 million Cambodians between 1975 and 1979, purportedly called land mines his “perfect soldiers.” They never sleep. They wait, with limitless patience. Although weapons of war, land mines are unlike bullets and bombs in two distinct ways. First, they are designed to maim rather than kill, because an injured soldier requires the help of two or three others, reducing the enemy’s

forces. Second, and most sinister, when a war ends, land mines remain in the ground, primed to explode. Only 25 percent of land mine victims around the world are soldiers. The rest are civilians—boys gathering firewood, mothers sowing rice, girls herding goats.

Despite its horrific history, Cambodia has now become a model for how a nation can recover from the scourge of land mines. There are more than a dozen programs for demining, land mine risk education, and survivor assistance in the country. The number of men, women, and children killed or injured each year by mines (both antipersonnel and antitank), explosive remnants of war, or IEDs has fallen from a high of 4,320 in 1996 to 286 in 2010. Survivors are offered medical and vocational

assistance. Every schoolchild is taught about the dangers of explosives. Contests have even been held for the best hip-hop songs about land mine awareness.

"I've been rude since I was young," a male performer boasts in one winning song. "I can only make things from bombs."

"No need to exaggerate and show off to me," the female chorus replies. "I don't care and don't want to hear about this."

Major minefields have been mapped and are being systematically demined. There's even a Cambodia Landmine Museum, created by Aki Ra. Located outside Siem Reap, a provincial capital, it displays the mines and ordnance that he deactivated. With support from Americans Bill and Jill Morse, who founded the Landmine Relief Fund, Aki Ra also cares for and educates 35 children at an orphanage.

Worldwide, millions of land mines are buried in nearly 80 countries and regions—from Angola to Afghanistan, Vietnam to Zimbabwe. That's one of every three nations. Many of them are following Cambodia's example. In 2002 almost 12,000 people worldwide were reported killed or maimed by land mines or other explosives. Since then, annual casualties have fallen to fewer than 4,200. This dramatic improvement is a direct result of the Mine Ban Treaty signed in Ottawa, Canada, in 1997, an international agreement banning the use, production, or transfer of land mines and calling for mandatory destruction of stockpiles. Today 157 countries have become party to the treaty, including Afghanistan, Liberia, Nicaragua, and Rwanda; but 39 countries have refused to join, including China, Russia, North Korea, and the U.S.

The American position is complicated. The United States has not used antipersonnel land mines since 1991, not exported them since 1992, and not produced them since 1997. But the nation has a stockpile of some 10 million land mines, and prior to the '90s, it exported 4.4 million antipersonnel land mines, an unknown number of which are still in the ground. Ian Kelly, a State Department spokesman, described the government's official position in 2009: "We

Selected as Miss Landmine Cambodia 2009, Dos Sopheap tries on her prize, a titanium leg, with pageant organizer Morten Traavik. Although she later found the leg too uncomfortable to wear, her fame brought her sponsorship for college.



would not be able to meet our national defense needs nor our security commitments to our friends and allies if we signed this convention." Nonetheless, under pressure from the United States Campaign to Ban Landmines, the Obama Administration has been conducting a comprehensive review of its land mine policy.

Despite its refusal to join the treaty, the U.S. has done more to counteract mines than any other country, spending \$1.9 billion during the past 18 years through the Humanitarian Mine Action Program—roughly a quarter of the total spent on demining and other remediation activities around the world. There's been a special emphasis on helping Cambodia, which has received more than \$80 million since 1993.

As in many countries, the vast majority of demining in Cambodia is done by hand. Demining



machines—30-ton, dinosaur-size rototillers that flail the earth to a depth of 12 inches—are exceedingly expensive. Only three are in use, along with 50 or so dogs trained to sniff out a mine. But in the end, a human must dig it out.

Demining operations have strict protocols. Outfitted in heavy, high-collared, crotch-protecting flak jackets and thick-visored helmets, a team of 10 to 25 deminers line up along the edge of a minefield with garden tools and a metal detector. Moving forward in yard-wide lanes, they first clear the vegetation from each three-foot-square block, then sweep the ground with the detectors. They toil straight through monsoonal rains and scorching heat, moving the detectors across the ground, listening for the telltale beep.

The salary is decent for Cambodia—about

\$160-\$250 a month—but money is not the main motivation. When Hong Cheat was five or six years old, a cow he was tending stepped on a land mine. The explosion killed his mother and father and blew off his right leg. He was surviving on the streets of Phnom Penh as a beggar when Aki Ra adopted him and trained him to be a deminer.

“I like to clear the land mines,” says Cheat. “I don’t want to see any more people like me in my country.”

THERE’S A NEW SENSE of hope spreading across Cambodia. The country is becoming a place

Mark Jenkins is a contributing writer. Lynn Johnson has taught photography to at-risk youths at National Geographic Photo Camps in Chad and Botswana.

Mosha was seven months old when a mine took her leg. Still growing at four, she's measured at a Thai animal hospital for a new prosthetic, essential since elephants carry so much of their weight on their forelegs.





where you can dream of a better life—and where sometimes, those dreams come true. Just ask Miss Landmine Cambodia.

Dos Sopheap, a young woman from Battambang Province, lost her leg to a mine when she was six years old. Her father, then a soldier, was carrying her in his arms through the forest at night when someone in front of them stumbled on a trip wire. Her leg was amputated high above the knee, and she has always used crutches with her false leg—until now.

To the tearful clapping of her family, Sopheap is taking her new titanium prosthesis for a test run around their dirt front yard, scattering the ducks and chickens. As befits a beauty queen, she is wearing a flouncy, peach-colored dress lit up like a rose by the setting sun. Her twin sisters hang on to each arm as she walks stiffly in circles, and her mother weeps.

Competing against 19 other women who had also lost limbs, Sopheap won the 2009 title of Miss Landmine Cambodia through an Internet vote based on her photo. She was awarded \$1,000 in cash and a \$15,000 state-of-the-art prosthesis. The beauty pageant was founded by Morten Traavik, an eccentric Norwegian theater director who organized the first contest in Angola in 2008.

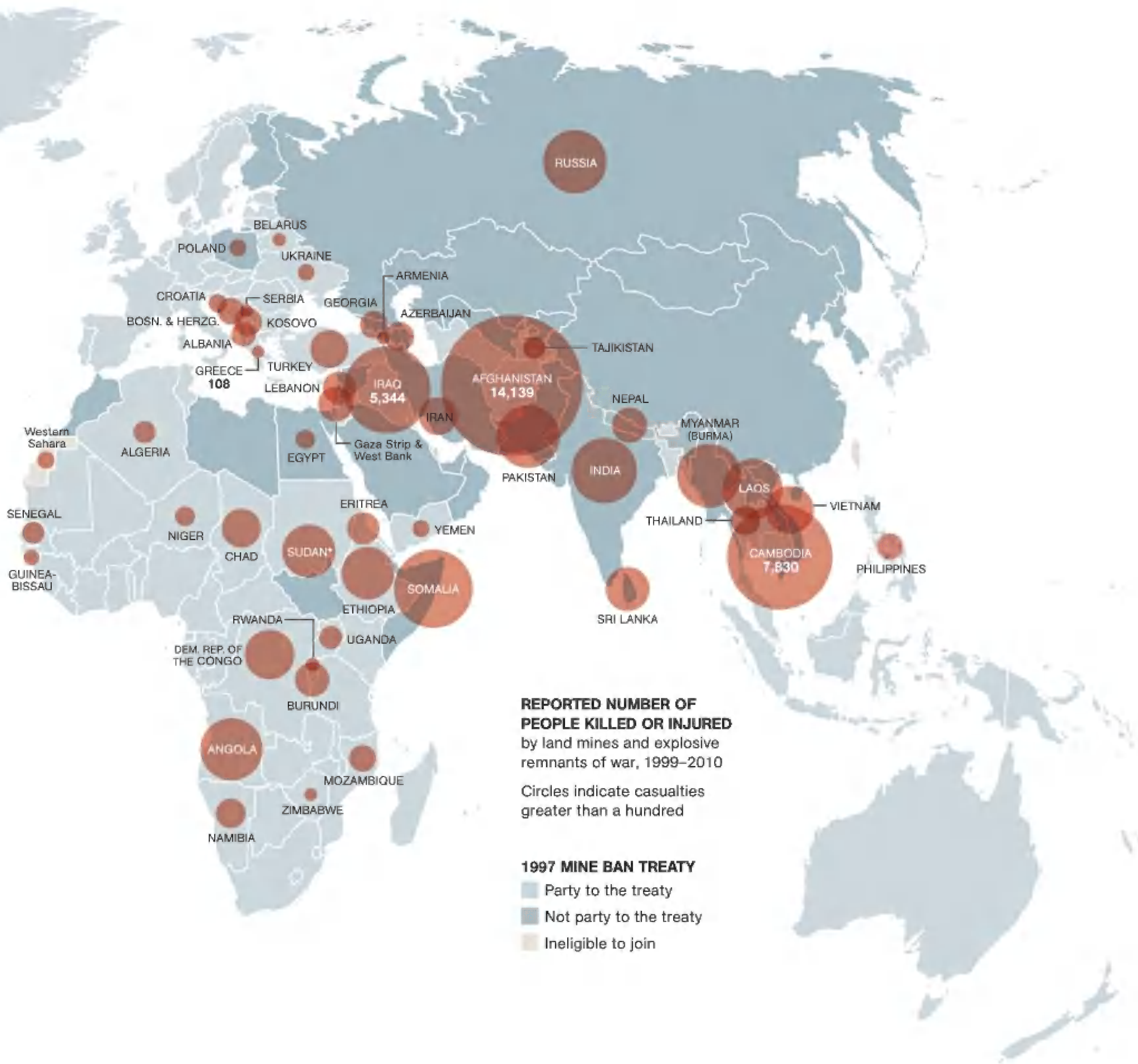
“The goal is to bring attention to the global issue of land mine contamination,” Traavik had told me earlier at a beauty parlor in Battambang where Sopheap was being coiffed and made up for a photo shoot, “and to make us think about how we, able-bodied people, look at disabled people, and not least how disabled people perceive themselves and present themselves.”

“It was so hard to watch other children run and play in the schoolyard,” says Sopheap’s mother. The other children teased the young girl. But that didn’t discourage her. Beautiful and quiet, she became a top student, ranking fifth in her high school class. The other kids now call her Miss Landmine, which pleases her. She hopes to become an accountant someday. Her mother later confides that Sopheap also “just wants to be like the other girls and be able to wear jeans.”



PEOPLE AREN'T THE ONLY victims of land mines. A country's economy is crippled too. More than 60 percent of Cambodians are farmers, who can't work a field if it's mined, can't earn an income, and can't feed their families. This is one reason why so many other mine-poisoned countries have struggled for so long after armed conflict has ended.

“There's a clear link between land mine contamination and poverty,” says Jamie Franklin of Mines Advisory Group (MAG), one of the major demining operations in Cambodia. Franklin



THE GLOBAL TOLL

Cheap and easy to deploy, land mines continue to pose a threat decades after conflicts end. More than 82,000 people were reported killed or injured by land mines and explosive remnants of war in 117 countries and regions between 1999 and 2010, according to the International Campaign to Ban Landmines. To date, 157 countries are party to a 1997 treaty to ban development, stockpiling, transfer, or use of land mines; 39 nations, including the United States, have yet to join the accord.

*Includes South Sudan
As of October 2011, Marshall Islands and Poland have signed but not yet ratified the treaty.

NGM MAPS
SOURCE: INTERNATIONAL CAMPAIGN TO BAN LANDMINES-CLUSTER MUNITION COALITION



has a large map of the country on the wall of his office in Phnom Penh. The eastern half is splattered with thousands of tiny red and purple dots, representing U.S. bombing raids during the Vietnam War. The western half is marked with hundreds of yellow squares, representing minefields. Unexploded ordnance and minefields are huge obstacles to increased agricultural production, which the government believes is necessary for economic development and recovery.

MAG has demined thousands of acres of contaminated land during the past two decades, including the village of Prey Pros in central Cambodia, where brilliant green squares of flooded rice fields shimmer as far as the eye can see. In Prey Pros, you can hear hammers and laughter. Crops have been good for the past

few years, and residents are building homes.

Thath Khiev, the village chief, bounced a naked baby on his knee while his wife stirred a cauldron of bubbling rice. Seventeen years ago, their world was very different.

"We did not have enough food to eat," Khiev tells me. "We could not grow rice on our own land because the soldiers had laid the mines." Prey Pros was once a garrison for Cambodian government forces. Two companies of soldiers were stationed here to protect a nearby bridge. To deter the Khmer Rouge, the bridge was mined and the village's rice fields were also heavily mined as a no-man's-land perimeter. Even footpaths in the village were mined. "It was very difficult," Khiev says.

MAG demined the area around Prey Pros in 1994 and 1995, removing 379 antipersonnel



At 14, Getu lost his left foot and had his right leg shattered by a mine while herding cows in Myanmar. Four months later, after infection set in, he was taken to Mae Sot Hospital (left) in Thailand for treatment. In a sign of Cambodia's renewal, a villager from Sneung (above) ventures into a recently cleared marsh to fish, once a life-threatening pursuit.

mines and 32 unexploded ordnance.

"Now we can walk safely to the rice fields and work freely without fear of mines," Khiev says. Tossing his grandson in the air, he adds, "It's safe for little children. If they want to swim in the river, in the lake, they can."

As villages and rice paddies like Prey Pros have been cleared, Cambodia's economy has grown stronger. In 1999, the first full year of peace, Cambodia had a gross national income (GNI) of \$10 billion and a per capita annual income of \$820; 11 years later, in 2010, the GNI had almost tripled to \$29 billion, and personal income had more than doubled to \$2,040.

Since 1992 demining has cleared about 270 square miles, but there are still some 250 square miles of contaminated land left. Currently, 23 to 31 square miles are cleared a year, which means

it will take another decade to rid Cambodia of mines and other explosives—a goal that has been achieved in less heavily mined countries like El Salvador, Honduras, and Albania.

"We simply cannot clear them fast enough," Franklin says.

EVEN THOUGH DEMINERS are still busy, Cambodia is no longer a devastated nation. Cities and villages throb with industriousness.

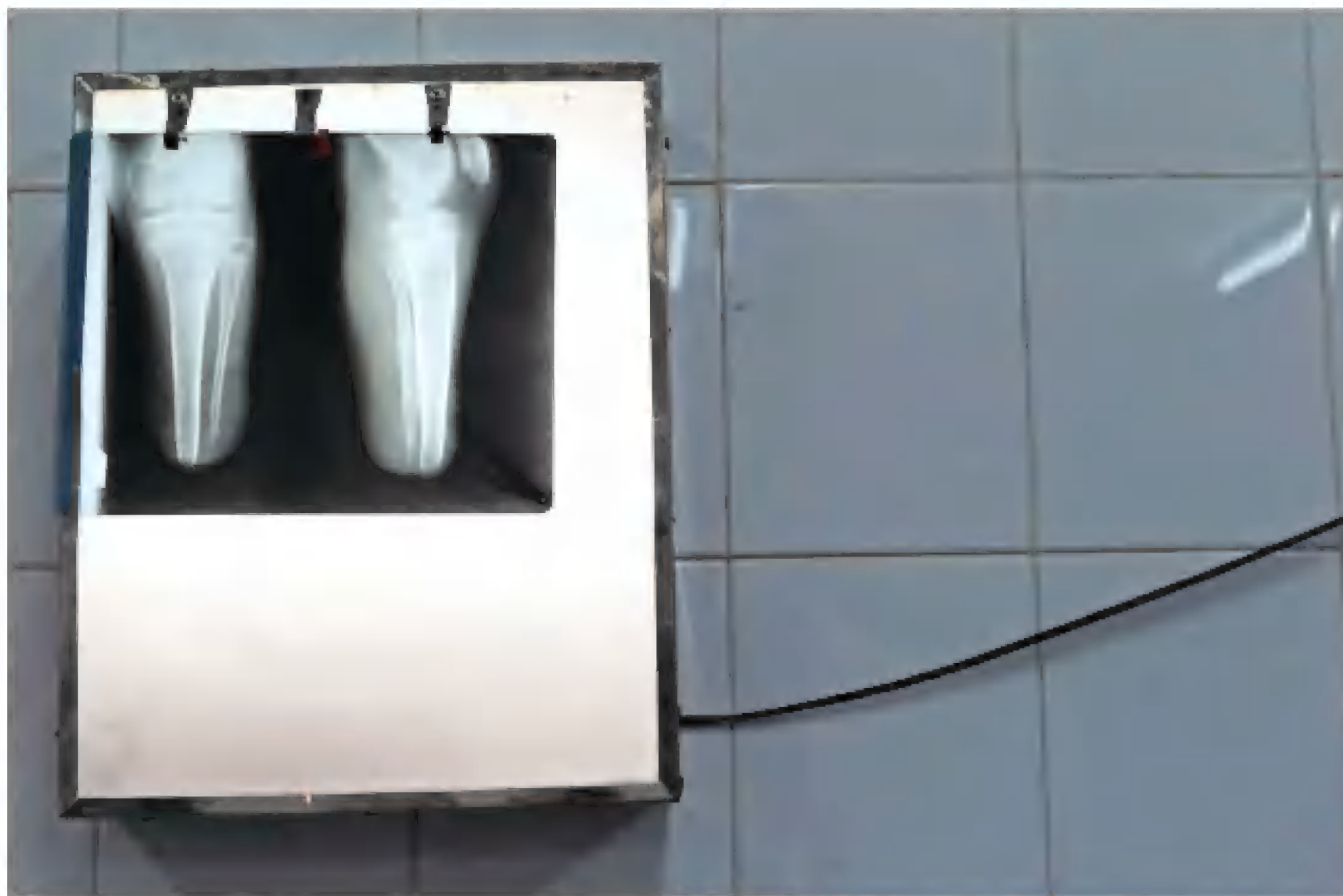
"We have a future now," says San Mao.

Short and muscled, Mao is an elite runner. He rises at four o'clock every morning to train, threading five miles through the wet, black streets of Phnom Penh. An hour later, after changing his curved fiberglass prosthesis for a rubber foot, he goes to work, whizzing around town as a motorcycle taxi driver.

Visitors to a bar pay to have fish clean dead skin from their feet while musicians, some missing legs, play for tourists in Siem Reap. As reminders of a painful past, mine survivors often face discrimination.







Students at an elementary school in Battambang Province (right) learn life-and-limb-saving rules by arranging cartoons in the best order to illustrate the hazards of land mines. Most sequences end with a fireball. At a Battambang hospital, an x-ray of a child's amputated legs (above) shows that his bones are still growing, making it painful for him to wear a prosthesis.

At five in the afternoon, he picks up his young daughter from school, then goes out for another run. His efforts have paid off.

Nine times in recent years, Mao has won the Angkor Wat International artificial leg ten-kilometer foot race, part of the Angkor Wat International Half Marathon, which was founded in 1996 to help land mine survivors.

He doesn't run just to win races. Running has calmed his mind. He used to get headaches from thinking too much about the past. "Now I focus on making a living for just one day, on eating for one day," he says, almost smiling.

Mao was a 15-year-old farm boy in 1987 when he was kidnapped by the Khmer Rouge. Soldiers dragged him away from his family into the jungle near the Thai border, forcing him to carry ammunition and refusing to

feed him. One morning he spotted fruit beneath a tree. The next thing he remembers he was lying in the mud, blood everywhere. The tree had been booby-trapped. "I cannot find anything to compare to the pain," whispers Mao. "I died there."

Three days later, unconscious but alive, he was found by other soldiers, who carried him to a hospital across the border in Thailand. Doctors amputated his leg below the knee. Upon returning to Cambodia, he began vocational training sponsored by Handicap International. That's where he met Ouch Vun, his future wife.

Today the couple live in central Phnom Penh with their daughter and ten other tenants. Their corrugated metal shack is set on stilts above a swamp with floating garbage. Inside, the walls are papered with pages from a pop culture



magazine. Mao's race medals hang from nails behind the TV.

When I visit, Regina, their seven-year-old, offers me a bottle of water, then sits in her father's lap. Ouch Vun hobbles over and places a whirring electric fan before me, then awkwardly seats herself beside her husband, tucking her sarong over her artificial leg.

Vun is so shy she barely speaks. Her eyes drop when I look at her. She tells me that her right leg was blown off in 1990 when she was digging for gold with her impoverished family. "When the doctor cut off my leg, I cried for months," she says.

Regina has been watching first her father, then her mother, tell their stories. Mao is stroking her hair, Vun lightly touching her arm. Unlike her parents when they were her age, she

can walk without fear of suffering the same fate.


A week later, on a mild December morning, a crowd of hundreds cheers the start of the Angkor Wat ten-kilometer race. It's a fitting location for the biggest race of its kind in Cambodia, with 50 or more runners. The famous ruins were once indiscriminately planted with land mines. Today Angkor Wat is one of the world's most popular tourist destinations.

When San Mao first comes into view, the clapping and cheering swell. Sweat streaks his cropped black hair; his round face is as calm as Buddha's. Whether he knows it or not, Mao is the embodiment of a country transcending its past. His feet, one muscle and bone, the other bowed fiberglass, are like wings. When they carry him first across the finish line, Cambodians erupt in jubilation. □

San Mao, a ten-kilometer race champion, gets ready for a training run in his Phnom Penh neighborhood. To support his family, he works as a motorcycle taxi driver in the capital. But he gets his joy from running.







The Salt and the Earth

In Africa's Afar depression, pastoral tribes and salt traders survive amid a surreal landscape of fissures, faults, and a boiling lake of lava.





Sulfur and algae turn hot springs into pools of living color. The water is condensation from hot gases rising from magma chambers. As the water evaporates, salts and minerals form a vivid crust.





Photographs by George Steinmetz

IT WAS LIKE A SCENE conjured by a Hollywood special effects shop. In September 2005 Afar herders in northern Ethiopia watched in amazement as the Earth yawned open and swallowed their goats and camels. Chunks of obsidian burst from subterranean caverns and flew through the air, said one local, “like huge black birds.” For three days a cloud of billowing ash dimmed the sun as the region’s largest volcano, Erta Ale—“smoking mountain” in the Afar language—erupted.

What set off these startling events? Miles below the surface a mammoth burp of magma had welled up between two tectonic plates, prying them farther apart. Aboveground, hundreds of faults and fissures opened along a 40-mile stretch of desert, swallowing unlucky livestock. More than a dozen smaller burps have shaken the area in the years since.

East Africa’s Afar depression is one of the world’s most geologically hyperactive regions.

Fly over it in an airplane—or in a one-person motorized paraglider, as photographer George Steinmetz did countless times—and it may appear as frozen and still as Arctic ice. But the Afar’s timeless visage hides its true nature. Below the surface, Earth’s rocky rind is ripping apart, and underground chambers of magma are fueling 12 active volcanoes as well as steaming geysers, boiling cauldrons, and a fiery lake of lava.

The 2005 quakes and subsequent rattlings are the latest in a long series of seismic upheavals that started some 30 million years ago, when magma pushed through the Earth’s crust and began splitting the Arabian Peninsula from Africa, creating the Red Sea and the Gulf of Aden. As the upwelling magma cools, it becomes denser and sinks. Some parts of the Afar now sit more than 500 feet below sea level.

Because of its low elevation, the Afar depression has been repeatedly flooded by the Red Sea, most recently about 30,000 years ago. After

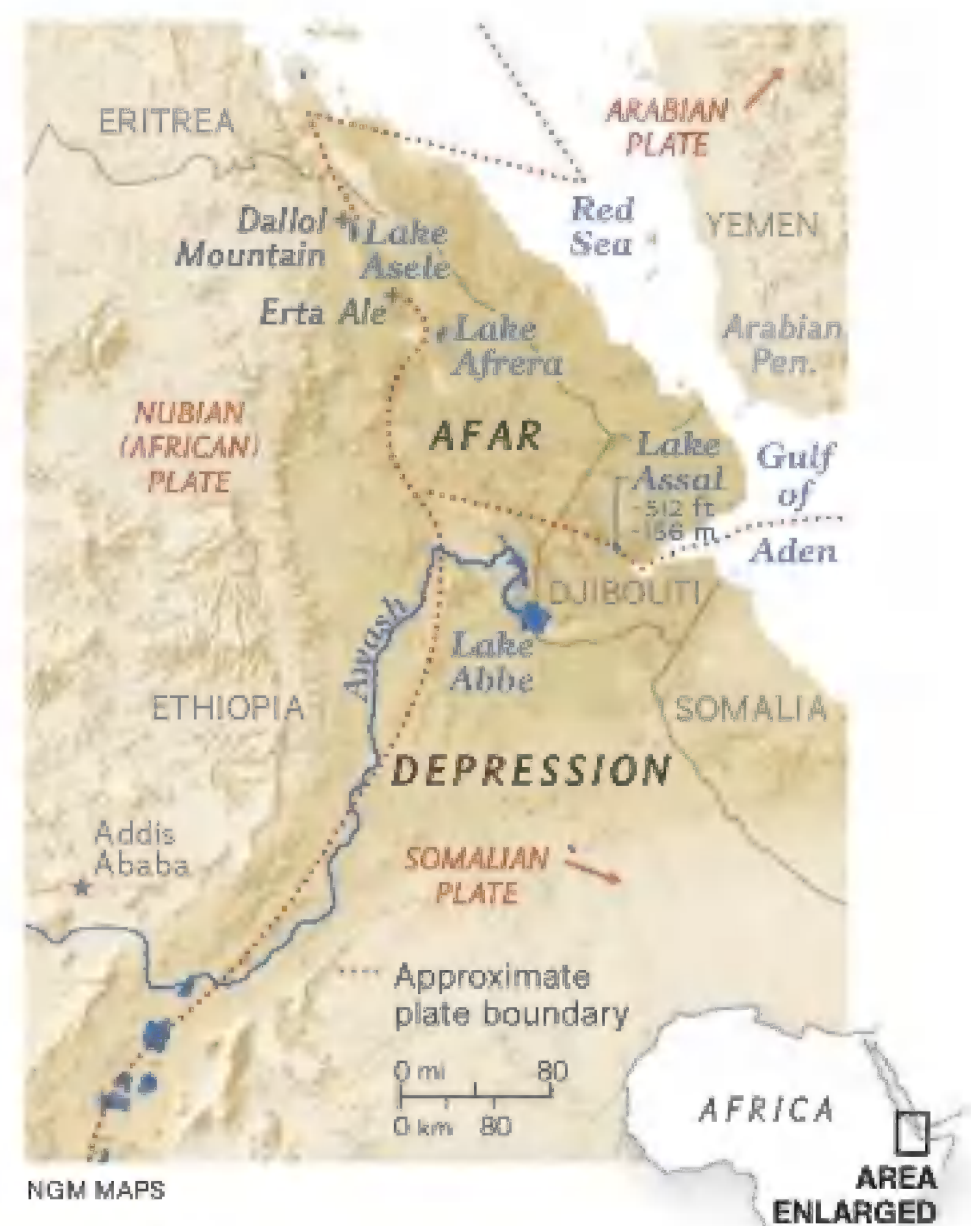


A lake of lava bubbles atop Erta Ale, the region's most active volcano (above). Groundwater heated to boiling goes up in steam at a geyser field northwest of Lake Abbe (left).

each incursion, the seawater evaporated, leaving behind thick layers of salt. This “white gold” has long been an important source of income for the Afar people, who remain fiercely loyal to this extreme land despite summer temperatures that can soar above 120 degrees Fahrenheit.

Scientists brave the desert's hardships for a different reason. The Afar is one of the few places on Earth where an undersea ridge—a jagged volcanic seam where magma oozes up and becomes new seafloor—emerges on land. This offers earth scientists the rare chance to study geologic processes that normally unfold far below the surface of the ocean.

Given enough time—at least several million years—those processes will produce dramatic changes in the geography of Africa: The Afar depression and the entire Great Rift Valley will cradle a new sea that connects the Red Sea to the Indian Ocean and cleaves the Horn of Africa from the continent. —Virginia Morell



Located at the intersection of three geologic plates, the Afar depression is caught in a tectonic tug-of-war that's splitting off part of the continent.

Evoking a scene from biblical times, caravans arrive at the salt mines of Lake Asele, 381 feet below sea level. For centuries salt blocks, called *amole*, were used throughout Ethiopia as money.







Ramparts of salt, mud, and potash, some 80 feet tall, rise above a maze of canyons and crags on the flank of Dallool Mountain. The tortuous shapes are the work of storms and flash floods.

Following pages: Sculpted by winds that consistently blow from east to west, sand dunes called barchans migrate across an ancient seafloor, rising about six feet and spreading 20 to 30 feet across.











RIDING OUT ANOTHER SEASON

*Harsh isolation didn't deter homesteaders
from making a life along northern Montana's Hi-Line.
Their tight-knit descendants show no less resolve.*

by DAVID QUAMMEN *photographs by* WILLIAM ALBERT ALLARD

Two sorrels (above) belonging to Buster and Helen Brown have gone AWOL in the snow.





A demolition derby in Shelby, Montana, plays out against a backdrop of grain elevators. Up here, agriculture is what turns the wheels of social and economic life.





Helen Brown knows the complications of passing a ranch to the next generation. Proud mother of two rodeoing sons, she told them, "Don't bring home any princesses."

The earnest saga of farming and ranching in northern Montana began with a misconception that verged on a lie: free land, enough to feed your family! But the land wasn't quite free, and it was far from enough.

A law had been passed by Congress back in 1862, codifying the misconception as a national promise. In exchange for building a house on a chosen site, planting a crop, and maintaining five years of residence, you could “prove up” on 160 acres. That is, you would be granted a title. The offer applied to all unclaimed federal land, much of it west of the Mississippi River, including what we now call Montana. The northern third of the eventual state, stretching roughly a hundred miles down from the Canadian border and westward as far as the front of the Rockies, comprised about 26 million acres of landscape, mostly semiarid plains upholstered with shortgrass prairie and sagebrush. The government wanted those acres occupied by white settlers whose presence would gradually erase the thought of land claims by Blackfeet, Gros Ventre, Sioux, Crow, and other native peoples. James J. Hill, founder of the Great Northern Railway, wanted those acres occupied by customers whose material needs (farm implements, horse tack, household goods, seed grain) and whose produce (mainly wheat) would fill his boxcars outbound and back. People came from Minnesota, from Illinois, from Scotland, from Norway, and from points in between to accept the dare, tossing down their labor, their youth, and their hopes onto a craps table with long, empty horizons that were green in springtime, brown in summer, brown in autumn, and then

Contributing writer David Quammen has lived in Montana for the past 38 years. William Albert Allard's career as a National Geographic photographer and writer spans nearly five decades.



implacably white. This was called homesteading.

Settlers arrived late to northern Montana, after the more easily farmable places had already been claimed. They followed the railroad, which Jim Hill's crews had completed in 1893. That rail line, in turn, had traced an old wagon trail across Indian lands. Congress updated the original Homestead Act in 1909, 1912, and 1916, shortening the residence requirement to three years and raising the allotted acreage to 320, or 640 for a cattle operation. Those changes, plus advertising hype from the railroad and misleading



A computerized combine and a grain-hauling semi help get the wheat harvested. Pricy equipment adds big debt to the risks and challenges of farming here.

encouragement from the crackpot mavens of something called dry farming, brought plenty of aspirants into the region, though time would show that the acreages were still far too small. Between 1909 and 1923, settlers filed 114,620 homestead claims in Montana, many of those within a day's wagon ride of the Great Northern line, which crossed the state at about 48 degrees north latitude. Population and service businesses, if not rain, followed the plow.

And so towns grew along that line, some named for faraway places and things: Glasgow,

Malta, Harlem, Havre, Inverness, Dunkirk, Kremlin. Some were named for people, such as Culbertson (a fur trader) and Shelby (a minion of Jim Hill). A few were more locally evocative: Cut Bank, Chinook, Poplar, Wolf Point. Eventually pavement as well as rails linked those communities, forming a portion of U.S. Highway 2, America's northernmost cross-country ribbon of blacktop. Within Montana, this stretch of road and railway and towns and surrounding landscape became known as the Hi-Line.

It's a part of the state that never appears in the

Marlboro ads or the ski brochures. Its beauties are severe and subtle and horizontal, rather than soaring and picturesque. It's not for everybody. But the Hi-Line contains scenes, lives, and voices with dramatic force all their own.

One of those voices belongs to Lloyd Kanning, a sturdy 76-year-old with a full head of white hair and pale blue eyes, who has been driving a tractor since the age of ten. "Farming," Kanning told me, as we sat in his living room in Shelby, "is like fighting a war."

HE LISTED THE CATEGORIES OF ENEMY. "You're fighting the weather to start with." You wait for the right moment, you put your seed in the ground—but if your tractor and other crucial pieces of machinery are old, you're fighting to keep them functional. Then diseases. Then bugs. Defeat all those, get a good stand of wheat grown and turning amber in the fall, "and along comes a hailstorm and beats it to the ground." Or if the hail doesn't find you, the wind does, whipping through your grain to cause "shelling" (kernels falling out of the heads) so bad you lose half your crop before you can cut it. But no, maybe it ripens fine, the hail and the wind spare you, the grasshoppers miss you, and you're ready to cut it—then comes a wet stretch of autumn days, sogging your harvest, forcing you to put damp wheat into the bin. Now you must aerate that bin and dry the grain, or at least keep it

It's a part of the state that never appears in the Marlboro ads or the ski brochures. Its beauties are severe and horizontal.

cool. "And then you've got to fight the price." If your wheat has low protein content, the buyer at the local elevator may discount you as much as a buck forty per bushel for every percentage point below scale. Say that high-protein wheat is selling at six dollars, and you're two points below; your crop might as well disappear.

"It does sound like war," I said.

"It is a war."

But these terms of engagement weren't apparent at first. Hopes ran high. A pamphlet issued in 1912 by the Great Northern Railway, titled "Montana Free Homestead Land," bragged that the state's climate was healthful, the winters "not severe because of the dry air," ha-ha, and the yields of winter wheat "phenomenal." Act now, urged the pamphlet. If you want a piece of this bounteous giveaway, it said, "you had better start for Montana at once."

Those good early years and dreamy expectations lasted through 1916. Then came a bad seven-year drought—not an extraordinary event, just a downward swing amid long-term cycles that the homestead promoters hadn't taken into account. The rains failed, and the formerly generous fields turned stingy. Lloyd Kanning remembers hearing of a wheat crop that his father planted in 1919. No rain fell that year, none, not to speak of, and the seed just lay unawakened in its rows. It sprouted in 1920, too late, adding insult to injury.

Elsewhere across the Hi-Line, conditions were equally grim. People did what was necessary to survive the hard times, scraping together some income from other sources, or else they just up and disappeared.

A young fellow from Minnesota named Henry Luken, who had homesteaded near Rudyard, which was a blip on the line, saw his wheat crop fail completely during one of the drought years. That winter he left the place, taking his only movable assets—four horses—and found work at a coal mine in the Bears Paw Mountains, about 50 miles away. With his saved wages, Luken bought feed for the horses, seed for another crop, and a summer's worth of supplies, then went back to his farm. Grasshoppers ate the second year's crop. He took his precious horses and returned to the coal mine for a second winter, worked hard again, saved, put all his wages once more into the farm. He also arranged a bank loan, for which his collateral was the horses. The third year, Luken grew a crop. He paid his debts and eventually bought more land—from other homesteaders, as they dried out and gave up—



The railroad put Montana's Hi-Line on the map a century ago, bringing in settlers and their supplies and carrying out—as it still does today—their harvested grains.

thereby enlarging his place enough to thrive in the good years and endure the next stretch of bad. That turned out to be one of the secrets of Hi-Line survival: Buy when you can, grow your place bigger, take the risks of expansion, not the risks of caution. I heard Luken's story from his grandnephew, Bob Toner, who owns a Tire Rama in Rudyard and still works that farm. Toner himself heard the tale many times from his father, who in 1934 came out from Minnesota to be Uncle Henry's hired man. The only reason Henry Luken managed to do what he did, he told Bob Toner's father, who told Bob, who told me, was that he had owned the four horses.

What was the secret ingredient of character that allowed some folk to prosper—or anyway, to continue—while others failed and gave up? Was it intelligence? Was it daring? Was it prescience, or some sort of ineffable green thumb?

"Tenacity," Lloyd Kanning said.

Others agreed. Dana Darlington's grandfather, born in 1906, lived in a sod homesteader's house with his widowed mother in southern Chouteau County and, when he got old enough, earned some cash rounding up abandoned livestock for the local bank. "It was pretty harsh. Lot of people were leaving," Darlington said, as his own mother served us hot chocolate and peanut butter cookies at her place, 20 miles southeast of Big Sandy. "When people left, they just up and left their livestock, just let 'em go." His grandfather's job was to bring in those cattle and horses

AREA ENLARGED



and mules before they starved or were eaten by cougars or wolves—collateral gone to waste. "It was pretty tough times, even before the Dust Bowl. The hoppers. The climate, dry. I think a lot of 'em that ended up staying just had a lot of luck on their side—and a lot of determination." Darlington himself, a solid, mid-fortyish man in a white-and-red flannel shirt and a blue silk neckerchief below his oval, browned face, exuded determination of his own. This was a cold day in November, with snow blowing like a grumbled warning, and he had just come in from feeding cows; the silk neckerchief, worn threadbare, was for warmth more than style. Four generations of family tradition will not end on his watch.

IT WASN'T JUST MAN against the elements. Quite a few of those original homesteaders were women, single or widowed, who made their way west and filed alone.

One among them was Vicki Olson's maternal grandmother, from Pennsylvania, who proved up on a place south of Malta in 1920, despite the drought. Meanwhile her brother and the man who would soon become her husband also filed and made good on their own homesteads nearby. During the late 1920s came some years





A calf roper warms up at the Marias 4-County Fair. While ranches and farms become ever more mechanized, rodeo is a reminder that the old skills are still prized—and useful.



Justin Hofeldt, a welder for BNSF Railway, repairs track near Rudyard. The rails opened this ground to homesteaders, with illusory promises of easy crops and plenty of rain.

of good rain, green rangeland for livestock, and high yields of wheat, which allowed some families to enlarge their holdings as vacated places became cheaply available. For Olson's paternal grandparents, sheep paid the bills, but it took much more than 640 acres to support a big flock. "Homestead days didn't work," she told me one afternoon at a Malta café, over the clink of spoons and forks against truck stop china. "This was hatched back East. Where they had all this fertile land. They didn't have a clue what the land was like here."

But some meliorating measures, too, were enacted back East, one of those being the Taylor Grazing Act, passed by Congress in 1934, which initiated the practice of leasing federal land to stock growers. Twelve years later, just after World War II, the U.S. Grazing Service became part of a newly created Bureau of Land Management, which nowadays continues to make western ranching possible by leasing public prairie for use by private cows. The terms and consequences of BLM leases can be debated heatedly for hours, but one result is that family cow-calf operations—at least some

of them, the lucky and stalwart and adaptable few—have survived. The Double O Ranch, which Vicki Olson runs with her sister and their two husbands, encompasses acreage that their grandparents put together, partly by purchasing failed homesteads, partly by acquiring 10,000 acres of BLM leases. If you think that sounds like a scenario for cattle grandees in the vein of Ben Cartwright on his Ponderosa, you mistake the proud parsimony by which such family ranchers make ends meet.

Dick Iversen's grandmother was another independent woman who filed on a place of her own. She came from Sweden via Minnesota and California, working in restaurants along the way, and arrived in Montana as a single mother with a young daughter. She homesteaded on a 160 just up the road from here, Iversen told me as we sat in the kitchen of his neat, modern ranch house amid the rolling hills south of Culbertson. Marie Youngstrom was the grandmother's name. She met his grandfather—another Swede, who drove the stagecoach—and they married, but not before each filed a claim (one homestead per head of a household, said the law). "They



Anna Scherlie, from North Dakota, filed a claim on a homestead near Turner in 1913. She lived alone in this one-room shack, without plumbing or electricity, until 1967.



had adjoining farms,” Iversen said. “And to the day she died, it was his farm and her farm.” She never ceased being head of a household.

I had left Wolf Point at 5:45 that morning, driving through the remnants of a blizzard at 18 below zero to be prompt for my 7:30 a.m. appointment. Ranchers rise early, and Dick Iversen had already finished spreading hay for the cows. His wife, Connie, had baked cinnamon cake, steaming and aromatic, which we ate as he talked about Grandma Marie. “She was kind of a matriarch-type person,” he said. Marie’s son eventually bought the father’s farm, but she clung to hers. She and the son then shared a yard, and there was tension. “That’s part of family farms that makes it difficult. The old farts don’t quit.”

He was speaking wryly, aware that he’ll soon be an old fart himself, but Iversen had touched on a key issue, one that arose often during my talks with people up there: succession. How do you transfer your place to the next generation? How do you retire? It’s not as easy as it sounds. Given that scale is crucial to economic viability,

ranches and farms that have been patched together by tenacious parents and grandparents can’t be broken into pieces for all the grown children. Nor can every son and daughter come home, with spouses and kids of their own, and rejoin the operation. There just isn’t enough income to support multiple generations of an extended family. One reason the old farts don’t quit is that they can’t afford to.

What was the secret ingredient of character that allowed some folk to prosper—or anyway, to continue—while others gave up?

“OTHER KIDS HAD SKATEBOARDS,” Buster Brown told me. “I had horses.”

Buster and his wife, Helen, run a cattle ranch and quarter horse operation in the Sweet Grass Hills, just short of the Canadian border northeast of Shelby, in a wrinkle of landscape too rippled, steep, and gully-cut for planting grain. Black Angus beef is their main product; well-bred and well-broken quarter horses are a sideline, with





Friends and neighbors gathered to help Maggie Nutter (pink cap) and Kelly Mothershead brand their calves. Afterward, beer slakes thirst and affirms a community moment.





Five generations of Gundersons have lived on the place that Anna Gunderson homesteaded in 1910. Her descendants come and go; the land remains.



A tense round of cow pie bingo enlivens a summer fund-raiser in Chester. The football field is gridded, bets are placed, and all wait to see where the flop will drop. Winner takes \$1,800.

its origins deep in Buster's childhood. When he was three, while his two older sisters attended a country school down at the corner of the section, his mother would send him out to hitch up his pony to a small wagon, ride down to the schoolhouse, and fetch his sisters home. The Browns' current line of equine stock goes back to cherished studs and mares with names such as Our Country Buck and Driftwood Doc. Buster and Helen's pair of strapping sons, B. J. and Jack, each inherited the equestrian talent and the passion. Both are rodeo athletes, riders and ropers, away at college during my visit but expected home for the holidays.

It was another chilly morning, ten below zero at dawn when I left Shelby, and now Helen's biscuits and gravy filled a place in my belly that the carryout latte and biscotti hadn't touched. As I sat at their kitchen bar, drinking black coffee, Buster spoke about his great-grandpa, John Brown, a blacksmith who worked on the trolley lines in Great Falls and then came up here to the Sweet Grass Hills and filed on a homestead around 1898. Elmer Brown was John's son, another blacksmith, who filed an adjacent claim

of his own. John built a log house, Elmer built one of frame, and eventually Elmer put them together, driving his frame house to the site like a horse-drawn wagon, holding his reins from one of the bedroom windows. He covered the frame and logs with stucco. That's the house Buster was raised in.

From those beginnings, his family had gradually grown the place, from 320 acres to roughly 10,000. After four generations, despite that growth or because of it, the ranch still wasn't paid for, not quite. How can that be? he asked himself, and then answered: "There just ain't that much cash flow."

"You're asset rich," Helen added, "and very, very cash poor."

The assets include not just acreage but also intangibles—such things as liberty, family continuity, texture of daily life, and a sense of the landscape. A nosy visitor might ask these good folks, as I have: "How has your family managed to stick it out? And why?" The first of those questions—the *how?*—starts a long conversation about weather, hard times, deep values, ingenuity, luck, adaptability, concern for the land,



The 4-H Club program, developing youthful skills and confidence, is another thread of the social fabric. Jayleen McAlpine of Sunburst shows her steer at the county fair.

sheer stubbornness, government policies (the hated ones and the depended-upon ones), global markets, and the protein content of wheat. The second question—the *why?*—is a conundrum to which responses tend to be poetic and terse.

Lloyd Kanning had mentioned tenacity. Bob Toner said, “It’s an excellent way to raise kids.” Craig French, from another old family, stood at the big windows of the house he has built on a rise 20 miles south of Malta, facing out over undulant prairie toward Beaver Creek. With his spotting scope on a tripod beside him, two pairs of binoculars nearby on end tables, he said: “I like getting up and looking at what I get to look at every morning.” He meant the land, the elk, the mule deer, the pronghorn, and the golden eagles, not his own cows.

Karen and Murray Taylor, 20 miles north of Devon, took my two questions deeply to heart. Murray, a lean man in a Glacier Motors cap, touched his wife amiably on the arm as she spoke. Her grandfather, from Norway, had homesteaded here in 1909. Now she and Murray would like to retire. But they have no pension,

no “investments” except their sweat equity in the farm. They call it the Circle 7, “because we have five kids, and we were a circle of seven, and we all built this place.” They could struggle for the rest of their lives, she said, or sell out and retire in ease. She showed me the album of photos from their harvest last year, a family event with 18 people, sons and daughters-in-law and grandchildren gathered and grinning amid the

Ranches patched together by tenacious parents and grandparents can’t be broken into pieces. There just isn’t enough income.

combines, the lunch wagon, the grain trucks full of golden wheat. “We want to see it succeed as a legacy,” Karen said. Any family farmers must feel the same way, she guessed, “or they wouldn’t still be here.” It’s not just something you do, with or without a good reason. It becomes “a part of who you are,” she said, then added simply: “Your identity.” I thought about that as I drove back to Shelby in the dark and the cold. □

EXHIBIT



Whales

Giants of the deep are revealed in this exhibit of National Geographic's best whale photography, opening January 23 at the Museum of the Earth at the Paleontological Research Institution in Ithaca, New York. Get tickets at museumoftheearth.org.



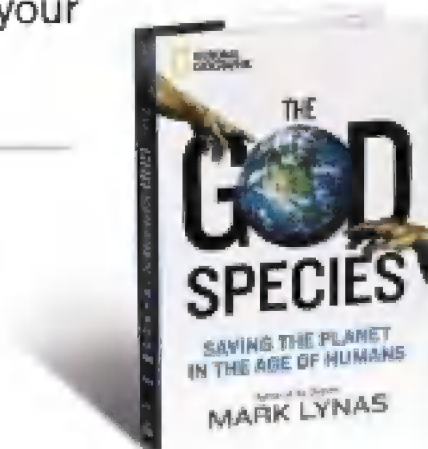
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BOOK

THE GOD SPECIES Award-winning author Mark Lynas examines the future of the "God species"—humans—in his new book. Lynas rethinks green ideology and explores how humans can use technology to save our planet. Available now (\$25).



LECTURE



INSIDE THE GENOGRAPHIC PROJECT Where did we come from? Geographic Explorer-in-Residence Spencer Wells shares the latest in his quest to map human migration through genes. With data drawn from hundreds of thousands of DNA samples, Wells shows how modern humans populated the world. Join him in the United States and Canada. For lecture details and tickets see nglive.org.

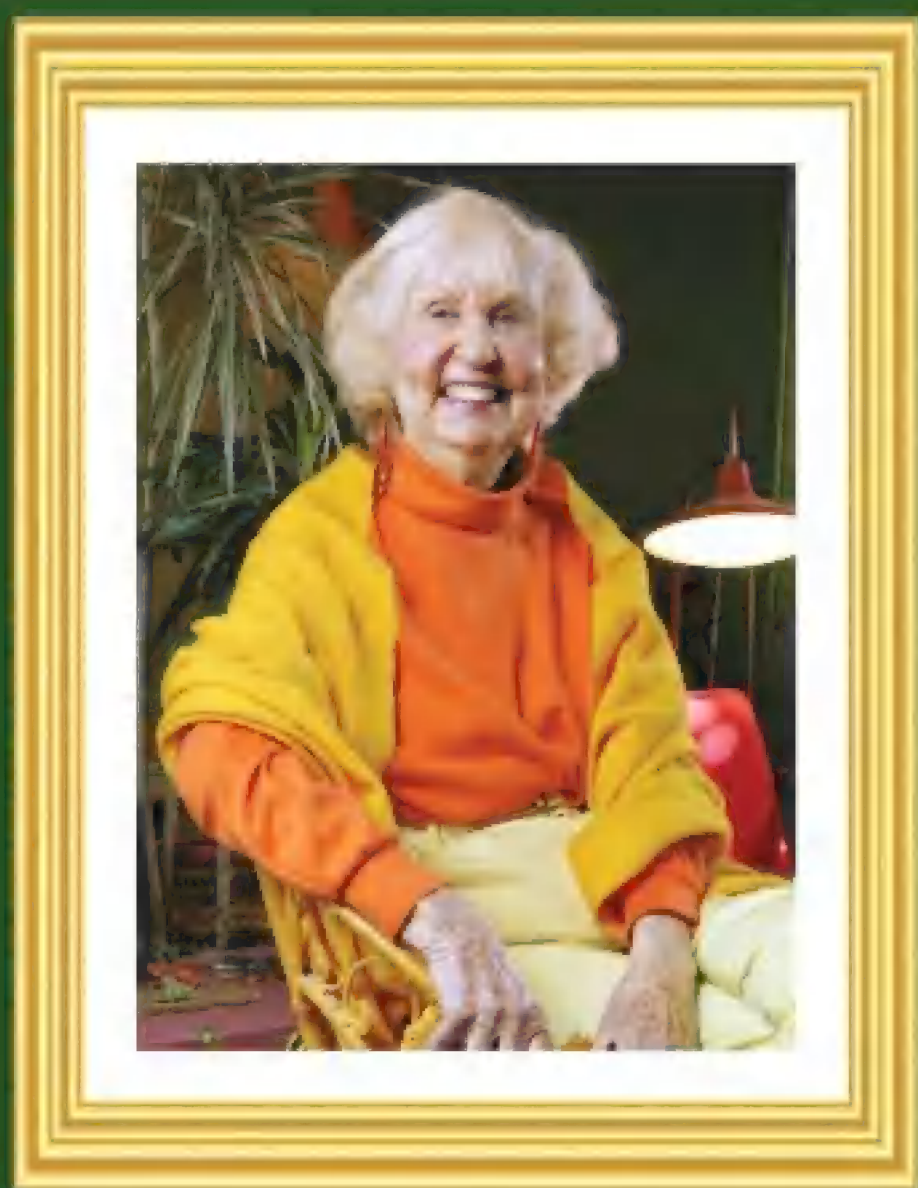
Free Download of the Month



Bajah + the Dry Eye Crew

Born from the ashes of one of Africa's worst civil wars, Sierra Leone's Bajah + the Dry Eye Crew has emerged as an international buzz band by filling stadiums at home, catching the ears of insiders everywhere, and charting a new course for global music. Download a free song from the group's self-titled album at natgeomusic.net/free.

Give An *Inspiring* Gift



Pat Minnick included National Geographic in her financial plans.

In 2007 Pat Minnick, a professional artist, decided to establish a charitable gift annuity to support National Geographic.

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Pat now receives a guaranteed life income and is a direct part of the Society's efforts to inspire people to care about the planet.

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At Home on the Range By the time this photograph of the IL Ranch cow camp in Nevada was made in 1979, Bill Allard had been photographing the American West for 13 years. Allard, who grew up in Minnesota prairie land, was smitten by high mountain meadows, the subdued palette of sage greens and beiges, and the men who worked there—cowboys with names like Floyd and Smitty who knew how a cow thinks and could pick out a horse from a herd with the flip of a rope. In 2007 the love affair became a commitment: Allard bought a house in Missoula, Montana, and he and his wife, Ani, now divide the year between there and Charlottesville, Virginia. —Cathy Newman



BEHIND THE LENS

Let's talk about what is going on in the photograph.

WAA: We'd been drinking whiskey the night before, and no one was doing a lot of talking. These buckaroos are going to get their horses shortly and round up cattle. I'd been camping with them and wandered off to take the picture. The empty chair is where I was sitting. The campfire is the social center of cow camp. Every night you end up around it, and you'll be there again in the morning.

What made you fall in love with the West?

I love the clarity of the air, the vastness of the space. The West has a world of sky. You can look around and see three or four different weather patterns unfold.

You've spent a lot of time with cowboys. Why do you admire them?

It's their independence. You can pick up your saddle and say: OK, I'm going somewhere else. A lot of us think we can do that, but very few of us do.

If, as you once said, "one thinks of a photograph as a one-act play," where in the script would this scene be taking place?

It could be the beginning of the play. Or the end. It's up to you to fill in the rest.

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WITH ANY PURCHASE

3-1/2" SUPER BRIGHT NINE LED ALUMINUM FLASHLIGHT
ITEM 65020/69052/69111
REG. PRICE \$6.99

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LOT NO. 877 **7 FT. 4" x 9 FT. 6" ALL PURPOSE WEATHER RESISTANT TARP**



SAVE 50%

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26837960

SUPER COUPON!

80 PIECE ROTARY TOOL KIT CHICAGO ELECTRIC POWER TOOLS



LOT NO. 97626/68986

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16741188

SUPER COUPON!

9 PIECE HIGHLY POLISHED COMBINATION WRENCH SETS



SAVE 40%

Item 42304 shown

SAE LOT NO. 42304/69043
METRIC LOT NO. 42305/69044

YOUR CHOICE! **\$5.99** REG. PRICE \$9.99

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14172591

SUPER COUPON!

WIRELESS DRIVEWAY ALERT SYSTEM



Bunker Hill Security
LOT NO. 93068

SAVE 53% Requires one 9 volt and three C batteries (sold separately).

\$13.99

REG. PRICE \$29.99

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21400512

SUPER COUPON!

PITTSBURGH 12" RATCHET BAR CLAMP/SPREADER



Item 46807 shown

SAVE 77% **\$1.99**

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26434807

SUPER COUPON!

800 RATED WATTS/ 900 MAX. WATTS PORTABLE GENERATOR



SAVE \$60 **\$89.99**

REG. PRICE \$149.99

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64363401

SUPER COUPON!

10/2/55 AMP, 6/12 VOLT BATTERY CHARGER/ ENGINE STARTER



SAVE 50%

\$29.99

REG. PRICE \$59.99

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SUPER COUPON!

2000 LB. ELECTRIC WINCH WITH REMOTE CONTROL AND AUTOMATIC BRAKE



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\$49.99

REG. PRICE \$99.99

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US*GENERAL 11 DRAWER ROLLER CABINET



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32943273

SUPER COUPON!

CHICAGO ELECTRIC POWER TOOLS 10" SLIDING COMPOUND MITER SAW



\$79.99

REG. PRICE \$139.99

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44922261

SUPER COUPON!

CENTRAL PNEUMATIC 3 GALLON, 100 PSI OILLESS PANCAKE AIR COMPRESSOR



LOT NO. 95275

SAVE 46%

\$39.99

REG. PRICE \$74.99

HARBOR FREIGHT TOOLS - LIMIT 4 This valuable coupon is good anywhere you shop Harbor Freight Tools (retail stores, online, or 800 number). Cannot be used with any other discount or coupon. Coupon not valid on prior purchases after 30 days from original purchase date with receipt. Offer good while supplies last. Coupon cannot be bought, sold, or transferred. Original coupon must be presented in-store, or with your order form, or entered online in order to receive the coupon discount. Valid through 4/27/12. Limit one coupon per customer and one coupon per day.



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Byrd Dogs Puppies pull a play sledge for the amusement of supply officer George Black during Richard E. Byrd's first Antarctic expedition. They were the offspring of the 94 dogs originally brought along for transport on the journey—and would soon be the youngest residents of a part of the camp called Dog Town.

“Oh Lord, all the perfumes in France couldn't have rid Dog Town of its gamy aroma,” wrote Byrd in a book about his travels, *Exploring With Byrd*. (This photograph ran in his August 1930 account of the 1928-30 Antarctic trip for *National Geographic*.) “The air in the tunnels was thick enough not only to be cut with a knife; spiced with a dash of garlic from the bulbs that hung over Noville's door, it could have been served as pemmican.” —Margaret G. Zackowitz

👉 **Flashback Archive** Find all the photos at [ngm.com](https://www.nationalgeographic.com).

PHOTO: CENTURY PARAMOUNT PUBLIX CORPORATION/NATIONAL GEOGRAPHIC STOCK

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